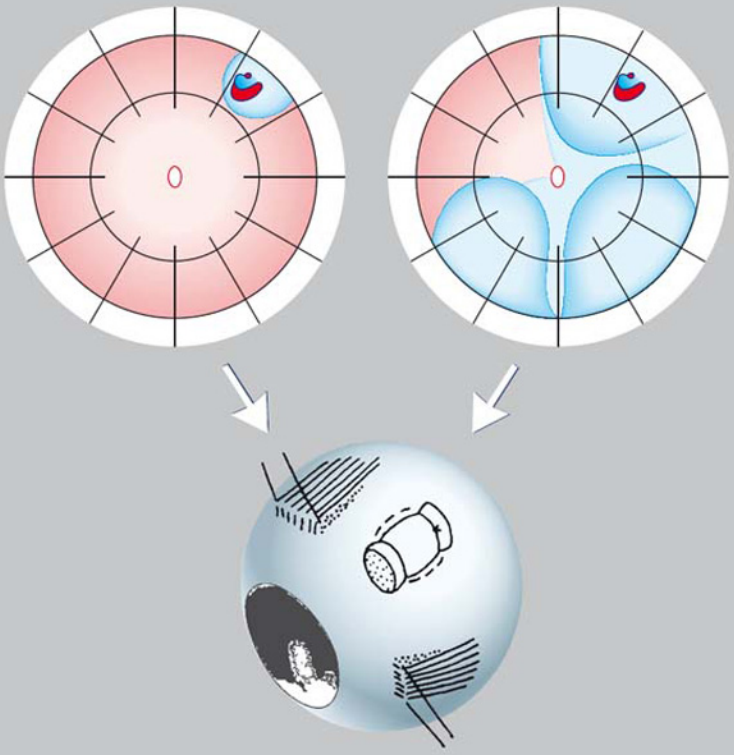
A Practical Guide to

Minimal Surgery for Retinal Detachment

1

Diagnostics · Segmental Buckling without Drainage · Case Presentations

Ingrid Kreissig



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Volume 1

Diagnostics · Segmental Buckling without Drainage · Case Presentations

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176 Illustrations

Thieme
Stuttgart · New York 2000

Library of Congress Cataloging-in-Publication Data

Kreissig, Ingrid.
A Practical Guide to Minimal Surgery for Retinal Detachment / Ingrid Kreissig.
p. ; cm.
Includes bibliographical references and index.
ISBN 3131110619 – ISBN 0-86577-781-0
1. Retinal detachment–Surgery. I. Title.
[DNLM: 1. Retinal Detachment–surgery. 2. Retinal Detachment–diagnosis. 3. Surgical Procedures, Minimal extraocular methods. WW 270 K91h 1999]
RE603.K74 1999
617.7'.35059—dc21

99-044473

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© 2000 Georg Thieme Verlag,
Rüdigerstrasse 14,
D-70469 Stuttgart, Germany
Thieme New York, 333 Seventh Avenue,
New York, NY 10001, USA

Typesetting by primustype R. Hurler GmbH,
D-73274 Notzingen, Germany
typeset on Textline/HerculesPro
Printed in Germany by Staudigl Druck,
Donauwörth

ISBN 3-13-111061-9 (GTV)
ISBN 0-86577-781-0 (TNY) 1 2 3 4 5 6

To Harvey,
one of the most perceptive thinkers in this field,
who has inspired my enthusiasm for retinal surgery
for over 30 years now.
He is the one who should have written this book.

Acknowledgements

I wish to express my utmost gratitude to Professor Lincoff, a superb teacher, researcher, and clinician, who provided me with constant support during my retinal work. In addition, I would like to thank all my other teachers, my students, the physicians who have referred their patients to me for diagnostics and treatment, and the various ophthalmologists from East and West who trained with me and challenged me with critical, but valuable questions.

Most of all my gratitude is extended to my family and to those very good friends—near and far— who gave me their full consideration and support while I was writing this book.

My particular thanks also go to Mrs Keller, who indefatigably typed and edited the manuscript with optimum cooperation, and to Mrs Jany who provided the computer images. The layout of the text—offering a didactic approach—as well as the quality of the figures can be attributed to the special efforts of Mr Rainer Hurler, a talented compositor, to whom I am very much indebted.

Finally, I would like to thank the staff at Thieme, in particular Mr Krueger and Dr Bergman, for realizing this project.

Preface

This book is intended to be handy to use and easy to understand. It is based on many years of teaching and research in retinal surgery. It analyzes diagnostic methods, differential diagnosis, and ways of achieving minimal extraocular surgery in the treatment of retinal detachment, from the learner's point of view.

The book is written in dialogue style so as to encourage critical and original thinking. It reflects everyday practice, and offers a hands-on guide to minimal retinal surgery.

Tuebingen, Fall 1999 *Ingrid Kreissig*

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1 Rhegmatogenous Retinal Detachment

1.1 Introduction

Retinal detachment is a separation of the sensory retina from the pigment epithelium. For the patient, it is a dramatic episode that causes a sudden loss of vision. Since Gonin [1], it has been known that the cause of detachment is a hole in the sensory retina. Retinal detachment occurs when fluid from the liquefied vitreous passes through the break and detaches the sensory retina from the pigment epithelium.

1.2 Vitreous Body

The vitreous body fills the vitreous cavity. It is a clear gel with a volume of approximately 4 ml. It makes up 80% of the volume of the eye and contains 98% water. It allows the transmission of light to the retina, and serves to conduct nutrients to the retina and the lens.

Liquefaction of the vitreous gel takes place with aging. Liquefaction is accompanied by a collapse of the collagen fibrillar network, and induces a detachment of the posterior vitreous from the retina. A posterior vitreous detachment is present in about 64% of patients over the age of 70. It can also develop earlier, in a myopic eye, an eye after injury (trauma, surgery), or after an intraocular inflammation. Complications secondary to separation of the vitreous are infrequent, but when they occur at the vitreoretinal interface they can result in various retinal disorders. The most serious form—a rhegmatogenous retinal detachment—is described here.

1.3 Precursors of Rhegmatogenous Retinal Detachment

Posterior vitreous detachment is usually an acute event. The patient perceives flashes, or photopsias, caused by the vitreous pulling on the retina as it separates. If a retinal vessel tears and bleeds, the patient may observe ascending black spots, known as “mouches volantes.” The drops of blood are actually falling, but the patient perceives them as rising, since they are behind the lens. This vessel tearing may be combined with tearing of the retina. Not all retinal

tears are preceded by flashes or "mouches volantes." The patient with an acute tear still has a complete visual field. It is when fluid from the liquefied vitreous passes through the tear and detaches the retina that an alert patient will perceive a black shadow at the edge of the visual field. A rhegmatogenous detachment has developed.

1.4 Characteristics of Rhegmatogenous Retinal Detachment

Having entered the subretinal space through the break, the vitreous fluid causes a detachment that has a convex surface and convex contours.

The characteristics of a rhegmatogenous detachment are therefore:

1. Convex surface and borders
2. Progression of the borders
3. Starting at the ora serrata, progression to the disk, and then dependently around the disk
4. Due to the action of gravity on the erect body, detachments originating from superior breaks (2/3 of retinal breaks occur in the superior temporal quadrant) are characterized by rapid dependent progression
5. Detachments from inferior breaks progress more slowly, and are more likely to develop pigment demarcation lines

A change has taken place in the management of retinal detachment in recent years. Instead of treatment being applied to the entire extent of the detachment, it is limited to closing the retinal break—the cause of the detachment.

Example (Fig. 1.**1**). In the diagram on the left, a small detachment has occurred around a break near 1 o'clock. The diagram on the right shows the same eye a few days later; the detachment has now extended to 2 quadrants. The cause of the 2 detachments is of course still the same, the break near 1 o'clock, and the treatment of

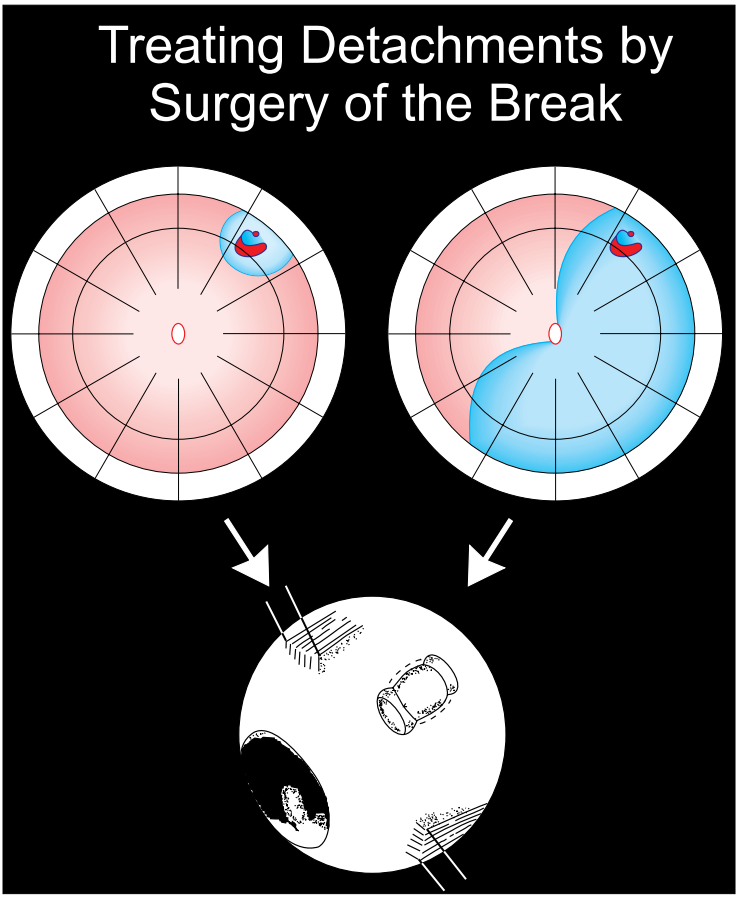

Fig. 1.**1** Treating detachments using surgery of the break. The left diagram shows a small detachment with a break at 1:15; the right diagram shows the condition in the same patient a few days later. The cause of the detachment is the same in both—the break at 1:15. The minimal approach is to tamponade this break, either with an elastic sponge sutured onto the sclera (see Chapter 8, p. 125), or, since the detachment has only 1 break, to use a temporary balloon buckle (see Part 2: Chapter 9. Temporary Balloon Buckle without Drainage).

the 2 detachments is the same—tamponade of the break. Figure 1.**1** indicates the rationale in the treatment of these 2 detachments. The problem, the break near 1 o'clock, is the same; the extension of the detachment is not relevant. (As you may know, this illustration represents the logo for our Tuebingen Detachment Courses, which has been used in publications since 1972 [2, 3]).

This change in the treatment of detachment represents a switch from using long circumferential buckles (cerclage) with drainage of subretinal fluid, to treatment limited to closing the break without drainage.

This operation was made feasible by:

1. The use of elastic buckles that effectively close the break and eliminate the need for drainage
2. Preoperative detection of all of the breaks using indirect ophthalmoscopy and biomicroscopy with contact lenses, both with depression of the periphery
3. Precise localization of the break at surgery.

The method known as the "nondrainage operation" is an extraocular detachment procedure. It was conceived by Custodis in 1953 [4]. Due to complications caused by the Polyviol explant available to Custodis, as well as the necrotizing effects of diathermy, the procedure was not widely accepted.

In 1965, Lincoff recognized the rationale and benefits of the Custodis technique, and by replacing the Polyviol plombe with a tissue-inert silicone sponge [5] and diathermy with cryopexy [6], the cryosurgical operation for detachment was developed. Initial skepticism concerning the strength of the cryosurgical adhesion was overcome by favorable results in a large series of animal experiments carried out by Lincoff and Kreissig [7–9]. The transsclerally induced cryosurgical adhesion proved to be as strong as, and more consistent than, diathermy, and it had the advantage of not necrotizing the sclera (as with diathermy).

This meant that a nondrainage procedure consisting solely of suturing an elastic buckle under tension over cryopexy-treated sclera could be achieved. The danger of impending scleral and choroidal perforation was eliminated. This operation is a minimal extraocular approach to the treatment of retinal detachment.

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2 Preoperative Examination

The success of minimal extraocular surgery in treating retinal detachment depends entirely on a meticulous and thorough preoperative examination of the entire retina up to the ora serrata, and on precise documentation of the findings.

The essentials and the secret of success are:

- Finding the retinal break, or all of the breaks
- Limiting the surgery to the area of the break or breaks by providing a sufficient tamponade
- Only then achieving retinal reattachment

It is the primary operation that determines the future of an eye with a detachment… but here you only get what you invest.

This means:

- *maximum* preoperative diagnostics
- providing conditions for *minimal* surgery, with
- *maximum* success.

2.1 How to Find the Break or Breaks

First, the patient is examined with binocular indirect ophthalmoscopy. It is preferable for the patient to lie supine on a stretcher (Fig. 2.**1a, b**). This provides optimal conditions for determining the correct borders of the detachment, and allows the patient's head to be tilted to either side as needed.

The defined contours of the detachment indicate the area in which to carry out the search for the primary break.

? What is a primary break?

▶ The primary break is the break which alone will cause the configuration of the detachment.

Identifying the borders (superior and inferior) of a detachment is extremely important for indicating where to search for the primary retinal break. Of course, the entire retina up to the ora serrata has to

Fig. 2.**1a** The patient is lying supine on the examination stretcher so that the borders of the detachment can be determined and the retina studied using indirect binocular ophthalmoscopy and depression. A drawing pad for precise documentation of fundus details is placed on the patient's chest.

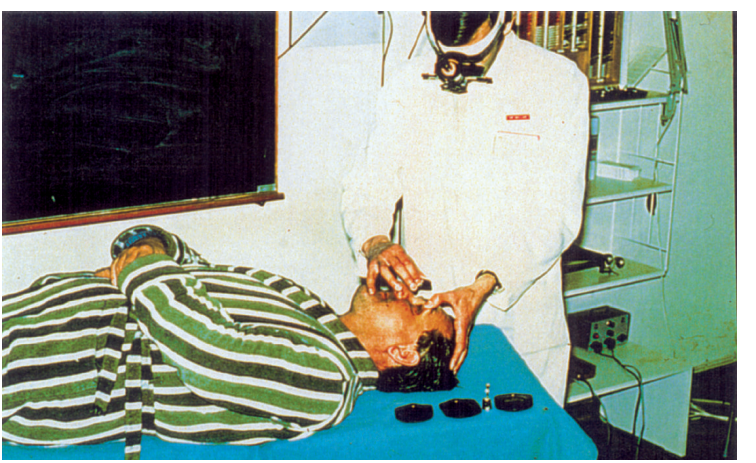


Fig. 2.**1b** To test whether the borders of the detachment that have been identified are correct, the patient's head is rotated to either side. The retina is studied using various lenses (at different magnifications), with simultaneous depression via the lid to make it visible up to the ora serrata. Depression is carried out with a thimble or a curved depressor (see Fig. 2.**3**).

be examined as well. To view the retina up to the ora, the periphery of the retina has to be indented through the lid, using a depressor.

The next step is to examine the patient at the slit lamp (Fig. 2.**2**) using various contact lenses, together with indentation of the retinal periphery. Indentation is essential, as it allows a hole to be distinguished from a harmless retinal lesion. The slender and slightly curved Kreissig depressor (Fig. 2.**3**) is well suited for this purpose. When it is applied in the presence of a contact lens over the lid, it provides a dynamic examination of the anterior retina (Fig. 2.**4**).

? How can the retinal hole be found in a pseudophakic eye?

▶ In the presence of a secondary membrane, or precipitates on the surface of the intraocular lens, or through a pupil fixed in diameter at 4–5 mm.

The recently developed indirect wide-field contact lenses for small pupils by Mainster, Volk, and Lincoff (see below Fig. 4.**2**) provide viewing fields of 125°, 130°, and 140° (comparable to the field obtained in indirect ophthalmoscopy). The indirect lens provides enough light to overcome the interference of most lens or capsular opacities. With these lenses, and some experience on the part of the surgeon, it becomes possible to examine the retina anterior to the equator, and pinpoint holes can be detected [1].

● **Returning to the topic of how to detect all of the breaks preoperatively:**

1. Use binocular indirect ophthalmoscopy, as well as:
2. Biomicroscopy with various contact lenses (the Goldmann lens for phakic and aphakic eyes, and the Mainster, Volk or Lincoff indirect contact lenses for pseudophakic eyes); the 2 techniques combined with depression of the anterior retina
3. Concentrate on searching for the primary retinal break, and apply the Rules of how to find the primary break [2–4].

These Rules rely on the contours of a detachment. This is why it is so important to define the correct borders of the detachment, with the

Fig. 2.**2** After indirect ophthalmoscopy, the vitreous interface and the detachment are studied at the slit lamp using various contact lenses, again with simultaneous depression of the retinal periphery. For precise documentation of the findings, it is helpful to have a desk on which the drawings can be made, set at right angle on the right of the slit lamp. The desk can also be integrated into the examining unit (see Fig. 2.**1**a).

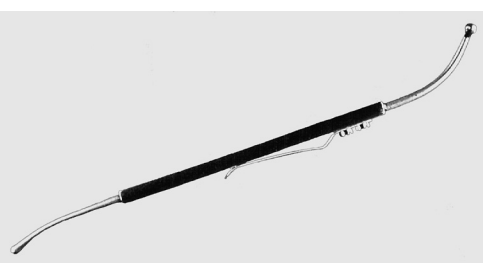


Fig. 2.**3** The Kreissig depressor has 2 curved ends corresponding to the curvature of the globe of the eye. The end with the small knob (left) can be used via the lid to depress the retinal periphery in the presence of a contact lens. The other end, with the mini-plombe (right), is often used with indirect ophthalmoscopy.

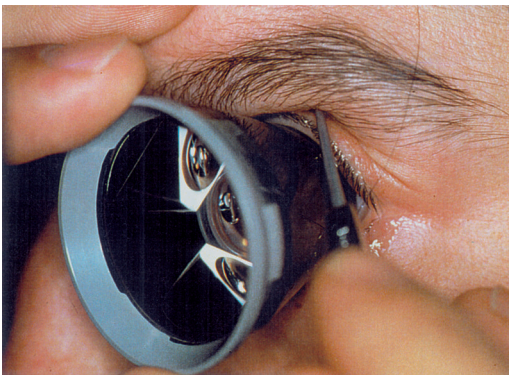


Fig. 2.4 Examination of the retinal periphery using a Kreissig depressor, applying the curved end with the small knob over the lid in the presence of a contact lens (photo courtesy of S. Dimitrakos, M. D.).

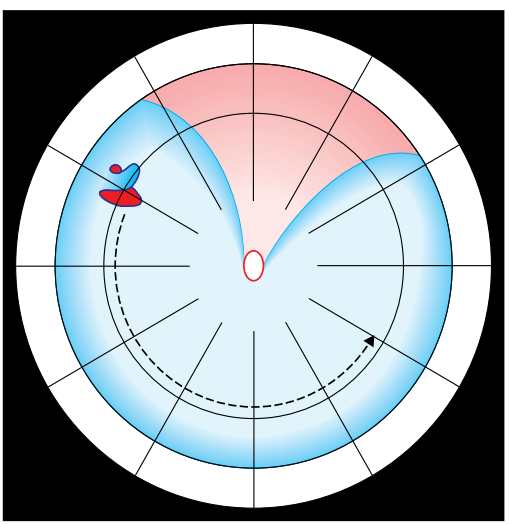


Fig. 2.5 A 3-quadrant detachment, with a horseshoe tear at 10 o'clock. Initially, the retina detaches in the area of the operculum toward the ora serrata. Subretinal fluid then progresses inferiorly and toward the disk, then to the 6 o'clock position, around the disk to the secondary side, and from there maximally as high as the hole on the primary side.

patient supine on a stretcher. The Rules are based on the principle that a detachment first develops around the break, then progresses to the ora anterior to the break, then continues dependently and to the disk.

The final shape of the detachment then depends on:

1. The position of the primary break and the gravity exerted on the subretinal fluid
2. The anatomical borders, such as the disk and the ora serrata
3. Retinal adhesions, if present—e.g., after prophylactic treatment or previous detachment surgery.

2.2 The 4 Rules to Find the Primary Break

Lincoff and Gieser [2] analyzed 1000 detachments and defined 3 patterns: superior temporal or nasal detachments; total or superior detachments that cross the 12 o'clock meridian; and inferior detachments.

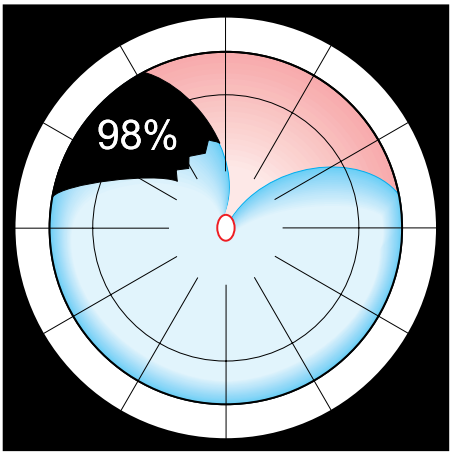
2.2.1 Superior Temporal or Nasal Detachments

Figure 2.**5** shows a detachment with a tear at 10 o'clock. To begin with, the horseshoe tear detaches toward the ora serrata, and the fluid then progresses slowly, with gravity, inferiorly and toward the disk, through the 6 o'clock meridian and then ascends around the disk to the secondary side, to a maximum height equal to that of the break on the primary side. Therefore:

Primary Break: Rule 1

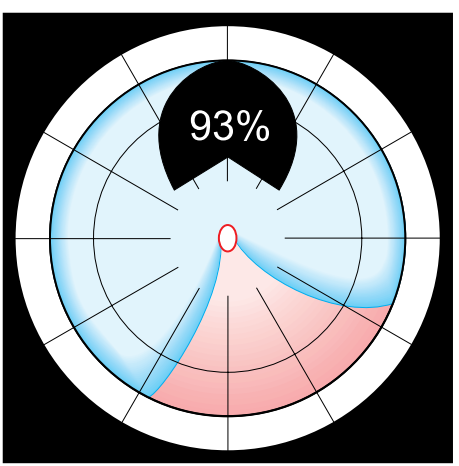
Superior temporal or nasal detachments:
The primary break that determines the shape of the detachment lies within 1 1/2 clock hours beneath the higher border of the detachment in **98%**. (Fig. 2.**6 a**).

This means that, in detachments with this configuration, a break will be found in this area in 98% of cases. However, this does not preclude the possibility that there is an additional break beneath it (or on a rare occasion even above it).



Rule 1:

Superior temporal or nasal detachments:
In **98%** the primary break lies within 1 1/2 clock hours of the higher border.



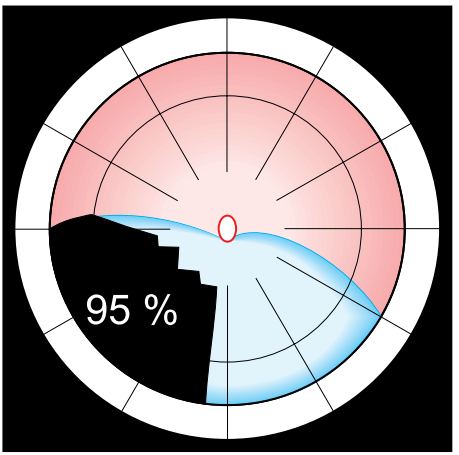
Rule 2:

Total or superior detachments that cross the 12 o'clock meridian:
In **93%** the primary break is at 12 o'clock or in a triangle, the apex of which is at the ora serrata, and the sides of which extend 1 1/2 clock hours to either side of 12 o'clock.

Fig. 2.**6 a** Rules 1 and 2 to find the primary break in a retinal detachment. The area in which to search for the primary break is outlined in black.

Rule 3:

Inferior detachments:
In **95%** the higher border of the detachment indicates on which side of the disk an inferior break lies.



Rule 4:

"Inferior" bullous detachments:
Inferior bullae in rhegmatogenous detachments originate from a superior break.

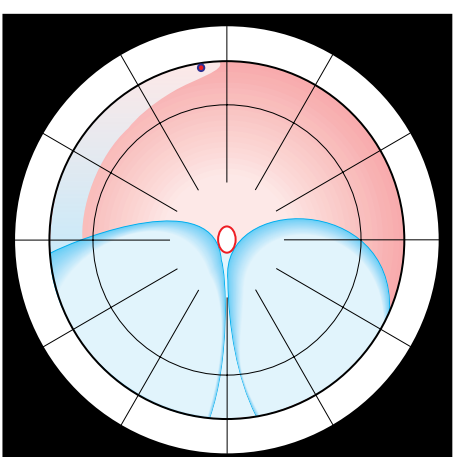


Fig. 2.**6 b** Rules 3 and 4 to find the primary break in a retinal detachment.

? Therefore, if surgery is limited just to the area of this break and the subretinal fluid is not drained, you have to be sure that you do not overlook another break. Why?

▶ If drainage is not carried out and a break is overlooked, the retina will only partially or not at all reattach after surgery, and the entire retina will only reattach completely postoperatively if all of the breaks are found and sufficiently tamponaded.

It should be borne in mind that, if you find and treat only a break that is more inferior than 1 1/2 clock hours from the superior border in the detachment, the chances of success will be small (in the range of 2%). The detachment therefore needs to be examined carefully, and both the primary break and any additional breaks that may be present have to be localized.

● Only a maximum of preoperative diagnostics will provide maximum success with minimum surgery.

2.2.2 Total or Superior Detachments that Cross the 12 o'Clock Meridian

Primary Break: Rule 2

Superior detachments that cross the midline at 12 o'clock and advance down both sides of the disk eventually become a total detachment:
In this type of detachment, the primary break will lie in a triangle the apex of which is at 12 o'clock and its sides are 1 1/2 clock hours to either side of 12 o'clock in **93%** (Fig. 2.**6 a**).

This means that in more than 9 out of 10 patients, the primary break that causes this type of detachment will lie in a triangle whose apex is at 12 o'clock. It should be borne in mind that the closer the hole is toward 12 o'clock, the closer it tends to be to the ora serrata.

2.2.3 Inferior Detachments

This type of detachment also has a convex surface, but it is not as bullous as the inferior portion of the 2 previous types of superior detachments. The break is inferior, i.e., below the 9 o'clock and 3 o'clock meridian, and the detachment is more likely to be shallow, because there is less gravitational pull on the subretinal fluid. The inferior detachment progresses slowly, if at all, and as a result it may develop pigment demarcation lines at areas of prolonged arrest. The retina may become atrophic, and intraretinal cysts may develop. The higher border of an inferior detachment indicates that side of 6 o'clock on which the break is located in 95%. This is the rationale behind the 3rd Rule:

Primary Break: Rule 3

Inferior detachments:
The higher border of the detachment indicates the side of the disk on which the inferior break is to be found in **95%** (Fig. 2.**6 b**).

2.2.4 "Inferior" Bullous Detachments

These detachments have special implications. Figure 2.**7** shows what appears to be an inferior bullous rhegmatogenous detachment. If only the inferior retina is examined, the apparent area of the detachment, a break will probably not be found—certainly not the primary break.

? The question is: Is this an inferior detachment?

▶ Remember that an inferior detachment originating from an inferior break is not bullous, and will not form a bullous cleft or fold.

The detachment in Figure 2.**7** is bullous, and has a fold. It might be an exudative detachment (discussed in Chapter 5, p. 63), but it is more likely to originate from a superior break and form part of a superior detachment.

The correct diagnosis can be made by examining the patient supine on a stretcher, and tilting his or her head to one side and the other. What is found is that the real contours of this "inferior" detachment change. Suddenly, a superiorly existing sinus appears and fills with fluid, demonstrating that the detachment is not only from 3 o'clock through 6 to 9 o'clock, but also extends (with the 9 o'clock side of the detachment in a dependent position) to 10:15 (Fig. 2.**8**). When the slightly detached area between 9 o'clock and 10:15 is examined, a small break at 10:15 emerges; it was previously not as visible, since it lay in what appeared to be attached retina. If the patient is laid on the opposite side (with the 3 o'clock side in the dependent position), the contour in the 3 o'clock area will not change.

This example demonstrates the importance of defining the "real" borders of a detachment, which then indicate the area of the primary break. Therefore:

Primary Break: Rule 4

Inferior bullae in rhegmatogenous detachments originate from a superior break (Fig. 2.**6 b**).

2.3 Some Special Types of Detachment

2.3.1 Inferior Detachment with a Hole at 6 o'Clock

Figure 2.**9** shows another type of inferior detachment. In this instance, the borders are symmetrical to 6 o'clock, and the detachment is not bullous. The differential diagnosis must include exudative detachment, of course. An exudative detachment is symmetrical both when the patient is in the sitting position and when the patient is lying down. It changes its contours and moves symmetrically superiorly on tilting.

However, if the patient in Figure 2.**9**, who has a shallow symmetrical inferior detachment, lies supine on a stretcher, the borders of the detachment will not change on tilting. This implies that it is a rhegmatogenous detachment with a hole exactly at 6 o'clock. As can be seen in this example, the borders of the detachment react precisely to the position of the hole.

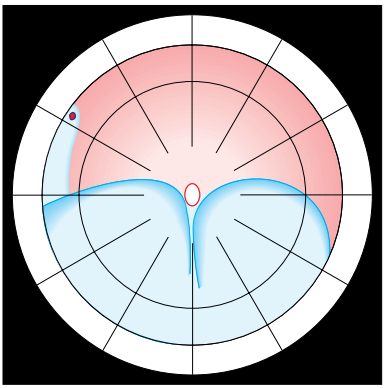


Fig. 2.**7** Bullous “inferior” detachment. If the patient is examined in a sitting position at the slit lamp, it is easy to overlook the tiny hole in the periphery at 10:15, since it is only connected with the bullous inferior component by a very shallow sinus in the far periphery.

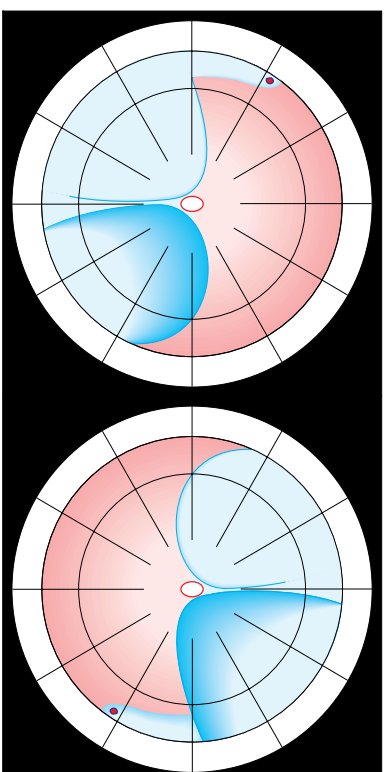


Fig. 2.**8** It represents the same patient as in Fig. 2.**7**, but in supine position. The head is first tilted to 3 o’clock (top). In this instance, the 3 o’clock border does not change. When the patient’s head is tilted to 9 o’clock (bottom), the border, which is now in a dependent position, changes. The detachment suddenly extends to 10:15, where a tiny break that was previously overlooked becomes visible.

2.3.2 Inferior Detachment in Presence of a Buckle

The inferior detachment in Figure 2.**10** is asymmetrical; it has convex borders, but is not bullous.

? Where would you expect the break to be?

▶ Actually, on the side beneath the higher border, i.e., on the 3 o'clock side. However, the break is at 7:30.

? Why is the break on the "wrong" side?

▶ In this instance, it should be recalled that preexisting scars or buckles can interrupt fluid distribution.

Due to scars from a previous buckle operation, this detachment cannot (as was to be expected) ascend any higher on the 8 o'clock side, where the break is found. The break at 7:30 may therefore be the only 1—but only assuming that the entire opposite side toward 3 o'clock has been carefully searched for another hole, without 1 being found. Certainly, the break in this detachment ought to be inferior, because the detachment is shallow.

2.3.3 "Total" Detachment

It is only at first glance that the detachment in Figure 2.**11** appears to be total. However, this can only appear to be so if the entire retina up to the ora is not examined (for instance, if the indentation is not applied through the lid to make the superior ora visible)—since only then could one conclude that this was a total detachment. Where would the break be located in a total detachment? Remembering **Rule 2**, it is clear that the break would be within $1^1/_2$ clock hours on either side of 12 o'clock.

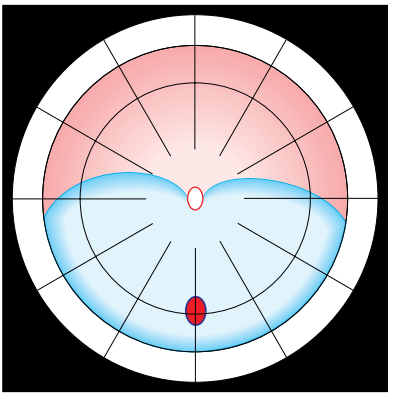


Fig. 2.**9** An inferior detachment with a hole at 6 o'clock. It should be noted that the borders of a detachment react very precisely to the position of the hole.

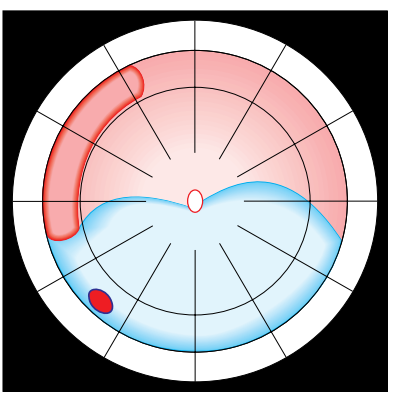


Fig. 2.**10** An inferior detachment in the presence of a buckle. The break at 7:30 is not on the "wrong" side, despite the fact that the border of the detachment is higher on the other side. This is due to an existing buckle interrupting the apparently correct fluid distribution.

But:
When this detachment is studied more carefully and with depression of the ora, a small wedge of attached retina will be discovered in the far periphery between 11:45 and 12:45. The detachment is not total, but extends from 12:45 through 6 o'clock to 11:45.

? What does this imply about where to search for the primary break?

This is not an example of a total detachment. Instead, the presentation is that of a superior lateral detachment, which means (according to **Rule 1**) that the search for a break should be carried out within **1 1/2 clock hours** of the higher border of the detachment, and not over 3 clock hours across 12 o'clock, as would have been necessary with a total detachment.

All at once, the diagnostic problem has become much smaller, and the range of possible treatments is also much reduced. In this patient, a break will be found at 11:30, and this area can just be buckled. This example again demonstrates the importance of determining the exact borders of a detachment up to the ora serrata, and taking into account the probabilities for the position of the primary break.

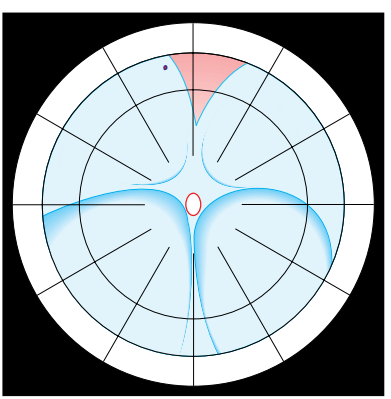


Fig. 2.**11** Apparent total detachment. However, when the retina is examined up to the ora, the detachment proves not to be total, but is a superior lateral detachment with an attached wedge of retina between 11:45 and 12:45. The break lies beneath the higher border of the detachment, at 11:30.

2.3.4 Mixed Detachment with Convex and Concave Components

In Figure 2.**12,** the break in the detachment lies to the left of the 6 o'clock meridian—apparently the "wrong" side, although the detachment ascends higher on the opposite side. Why? Carry out a critical and careful examination of the contours and surface of this detachment—remembering that a rhegmatogenous detachment is caused by a break and has convex surfaces and convex borders.

? When you analyze this detachment, what do you find?

▶ The detachment represents a mixed type. There are 2 areas of convexities of rhegmatogenous origin, and a concave area due to traction.

The left convexity is higher, rising to the 9 o'clock level. It is therefore on this side that the primary break is likely to be found—and there is one at 7 o'clock. When you look carefully, it can be seen that the convex border toward 3 o'clock is actually more inferior, so that the break fits the convex portion of the detachment with the break at 7 o'clock. What about the component of the detachment that ascends to the 1 o'clock level in the periphery? On closer examination, it can be seen that this part of the detachment is not convex, but

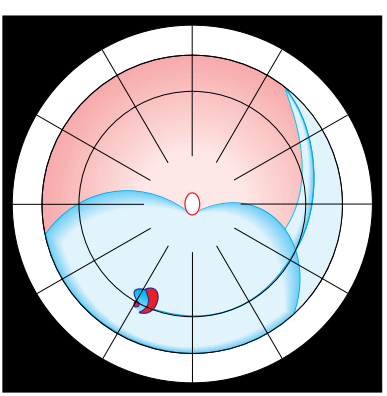


Fig. 2.**12** Mixed detachment with convex and concave components. The tear at 7 o'clock is apparently on the "wrong" side, since the detachment ascends further up on the other side. However, when this detachment is analyzed more carefully, it can be seen that the tear is actually on the higher side of the rhegmatogenous (convex) component of this mixed detachment. The concave component extends from 1 to 4 o'clock, due to traction in the periphery.

concave. It has a concave border and concave surfaces, and the retina is elevated in a tent shape due to vitreous traction. The concave contour and surface of the detachment provide reassurance that it is not caused by a retinal break.

● In this mixed type of detachment, it is only the break that should be treated. If you buckle it, the convex portions of the detachment will reattach. Only the concave detachment should remain.

In this patient, the small tractional detachment in the anterior retina disappeared after several months, and this often happens.

? **What should you do when you do not find a break, and you still suspect a rhegmatogenous detachment?**

▶ You should continue to search for the break, otherwise the surgery will not succeed, or you will have to use maximum—i.e., excessive—surgery.

Often, the break can be discovered after repeated examinations. For minimal surgery to be possible, it is necessary to find the primary break. If the break is not found, there is an inclination to carry out surgery on the entire detachment, which involves excessive surgery and frequently fails. The correct way to proceed while still using a minimal surgical approach in a detachment without an apparent break is discussed in Chapter 4, p. 41.

2.4 Summary

- The success of retinal surgery should not depend on the day you have scheduled surgery, but more on the day you find a solution that fits the detachment and promises 95% odds for reattachment.
- A precise drawing of the fundus and the position of the breaks will guide you at the time of surgery.
- Never forget to search for additional breaks that might be present in addition to the primary break. Remember that there is:
  1 break in about 50% of detachments, but
  2 breaks in 30% and
  3 breaks in 20%,
  and that they tend to be located within 1 quadrant of the primary break.
- **A minimum of extraocular surgery for a rhegmatogenous detachment can only provide a maximum of success if it is preceded by a maximum of search for the break or breaks.**

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3. Kreissig I. Gezielte Ablatio-Diagnostik nach Lincoff zum Auffinden des Netzhautloches. Klin Monatsbl Augenheilkd 1973; 163: 314–23.
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3 Acute Rhegmatogenous Vitreous Hemorrhage

3.1 Precursors of Retinal Detachment in the Presence of Vitreous Hemorrhage

Before discussing the management of intraocular hemorrhage—described in 1975 by Lincoff and Kreissig [1]—it may be useful first of all to recall a few details about the precursors of retinal detachment. The precursors can be flashes or spots, which are caused by the detaching vitreous pulling on the retina. If a small vessel becomes torn, the patient will perceive the drops of blood as black spots or "mouches volantes". At this point, the patient may still have full visual acuity and a complete visual field.

But:
If the patient reports a sudden onset of masses of black spots that ascended in streaks and caused a clouding of vision, then a large retinal vessel has been torn, and a substantial quantity of blood has been released into the retrohyaloidal space.

Tearing of a vessel can be associated with tearing of the retina, so the retina may already have started to detach.

? What should be done?

3.2 Topography of Acute "Vitreous" Hemorrhage

As long as the patient is still able to perceive a complete visual field (even though it may be tinted red), and as long as the light projection is correct, it can be assumed that the retina is attached.

To begin with, examine the patient using indirect ophthalmoscopy. Some retinal details may be visible. The peripheral retina is almost always visible if the blood is still in the **retrohyaloidal** space (Fig. 3.**1**).

But:
First examine the fellow eye to exclude other causes of vitreous hemorrhage, such as proliferative diabetic retinopathy or other retinal vascular disorders that can have symptoms in both eyes.

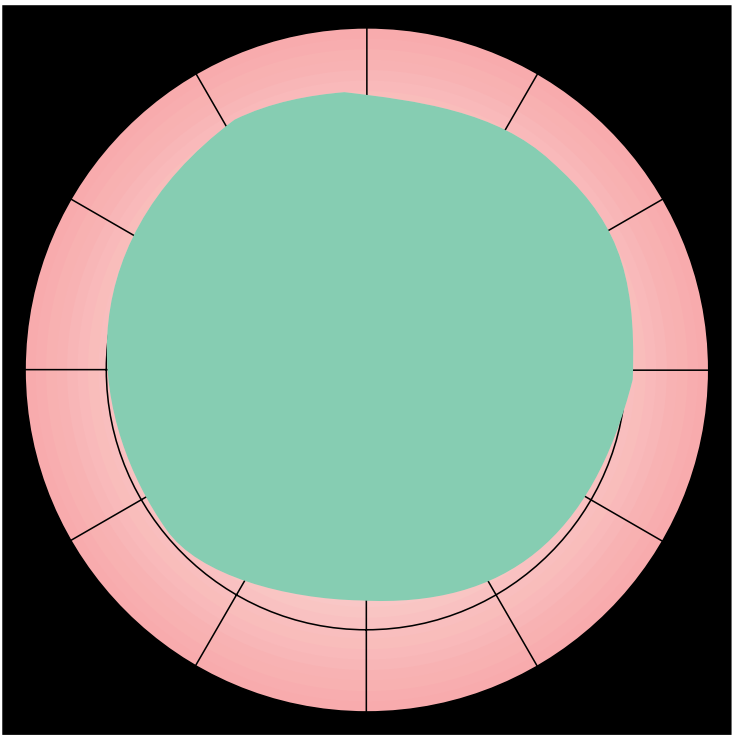

Fig. 3.1 *“Vitreous”* hemorrhage. At the slit lamp examination, the vitreous is seen to be free of cells; the cells are in the *retrohyaloidal* space, obscuring the view of the retina. With a contact lens, the peripheral retina is visible, since in this area the vitreous is still attached and there are no retrohyaloidal blood cells obscuring the view.

In the absence of vasculopathy in the other eye, what can the cause of the hemorrhage be? The most likely cause is a rhegmatogenous vitreous hemorrhage caused by a torn vessel or retinal tear, or both. Hemorrhage caused by neovascularizations secondary to a previous branch vein occlusion is less frequent. Venous occlusion can usually be excluded on the basis of the patient’s history, or by consulting the patient’s doctor.

In the absence of vasculopathy in the other eye, it can be assumed until proven otherwise that an acute vitreous hemorrhage is caused by a retinal tear [2].

If no details of the fundus are visible, even in the periphery, an examination by ultrasonography can be carried out to answer the following questions:

? **1. Is the vitreous detached?**
2. Is the retina still attached?
3. Can the flap of a tear be detected?

Next, examine the patient using biomicroscopy of the vitreous. If this shows that the vitreous gel is free of blood cells, it means the cells have collected on the posterior surface of the hyaloidal membrane, and are circulating in the retrohyaloidal space (Fig. 3.**2**). The retrohyaloidal space is a chamber filled with fluid (not gel), and the movements of the eye can maintain the red blood cells within it in suspension. There is also a weak convection current.

3.3 Conservative Management

? **What can be done to reduce the circulation of the blood cells that are obscuring the retina?**

▶ Eye movements can be minimized by double patching the patient. If the patient's head is elevated at the same time, the blood cells will settle. The treatment can be started in the office:

Double patch the patient for several hours, and have the patient sit upright.

Lunch can be provided. When the patches are removed at the end of the day, the patient will be able to see you—as if by magic—since the retrohyaloidal blood will have settled (Fig. 3.**3**). Immediately, study the fundus using biomicroscopy to identify the cause of the hemorrhage. Usually, there will be a flap tear with a torn vessel crossing it (Fig. 3.**4**).

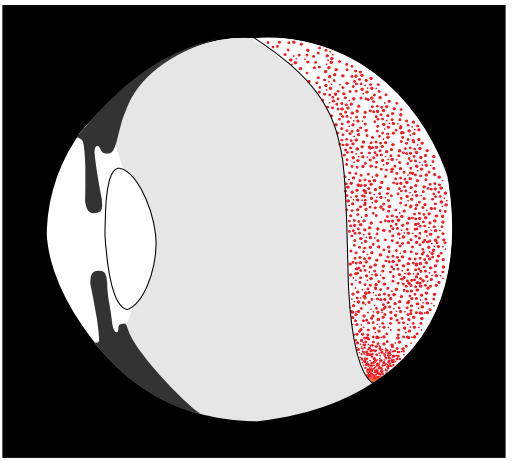

Fig. 3.**2** Sagittal section of an eye with acute "vitreous" hemorrhage. The vitreous gel is free of cells. There are red blood cells coating the external surface of the hyaloidal membrane and circulating in the retrohyaloidal space, obscuring the view of the retina (cf. Fig. 3.**1**).

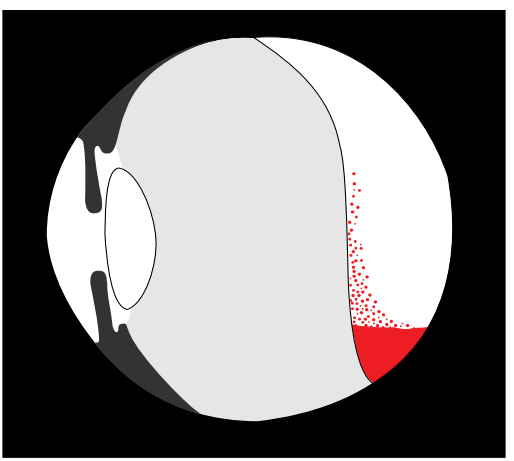

Fig. 3.**3** Sagittal section of an eye after double patching and elevation of the patient's head for several hours. The blood cells have settled to the bottom of the retrohyaloidal space. It is now possible to examine the retina to see whether there is a tear (cf. Fig. 3.**4**).

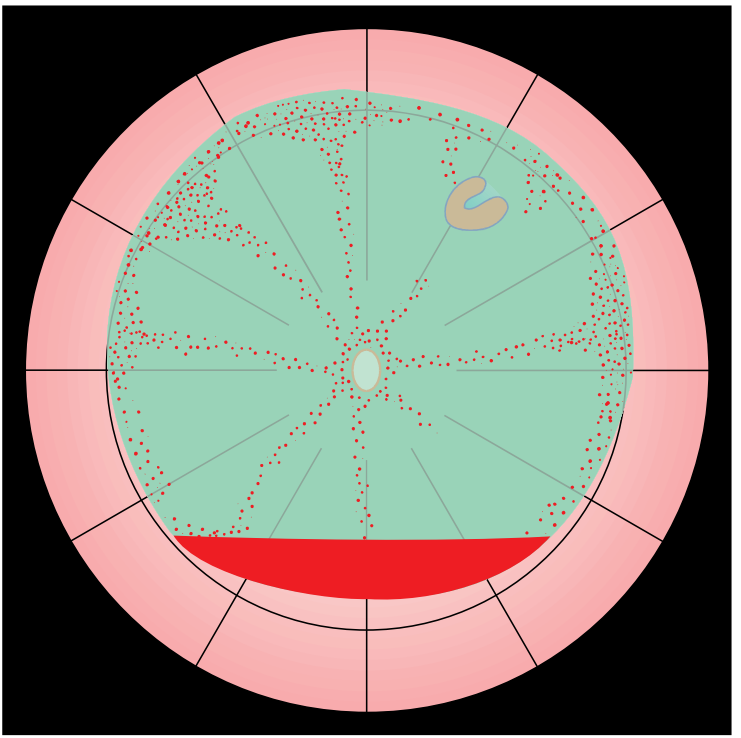

Fig. 3.4 View of the retina after double patching and elevation of the patient's head for several hours. The blood has settled to the bottom, and collected in the area of the vitreous attachment. A horseshoe tear at 1 o'clock becomes visible, and can now be treated.

- If the edges of the tear are attached, treat it straight away using laser coagulation or cryopexy (Fig. 3.5). If the facilities are not available, the patient should be sent elsewhere for treatment right away double patched.
- After this treatment, it is still mandatory to maintain the double patching and keep the patient's head elevated, so that the blood will stay at the inferior vitreoretinal insertion.

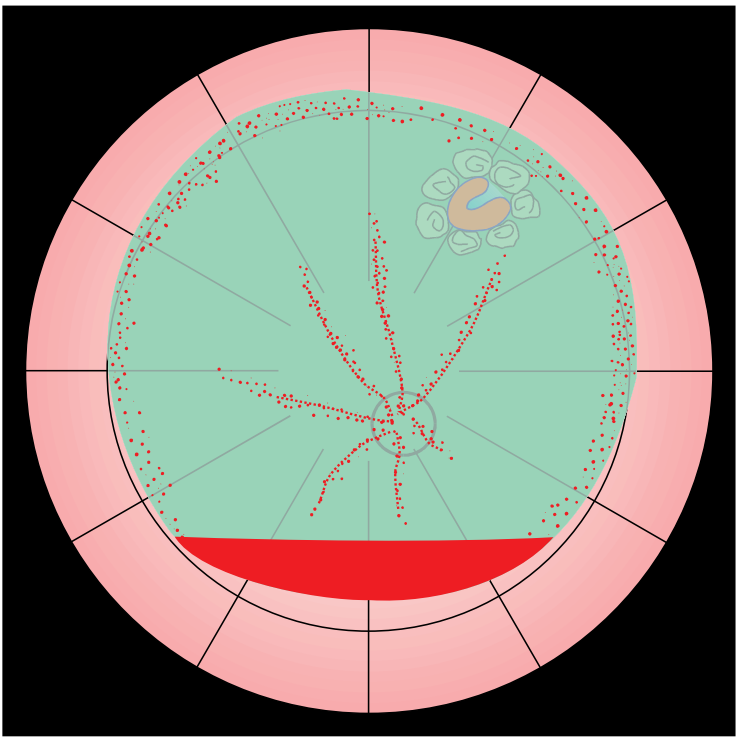

Fig. 3.**5** The same patient as in Fig. 3.**4**, but 3 days after treatment of the attached horseshoe tear with cryopexy. Double patching and elevation of the patient's head are continued, because tears in the posterior hyaloidal membrane will develop and blood will enter the vitreous gel (see Fig. 3.**6**).

During the night, the patient should keep both patches on and keep the head elevated at an angle of 30° until the blood is absorbed. Otherwise, the blood will enter the vitreous gel through the holes that develop in the posterior hyaloidal membrane during the following days. As Lincoff and Kreissig have described it [1], these tears in the posterior hyaloidal membrane seem to start in the area at the edge of the disk. Vitreous gel can prolapse through the holes and come into contact with the blood in the retrohyaloidal space, if

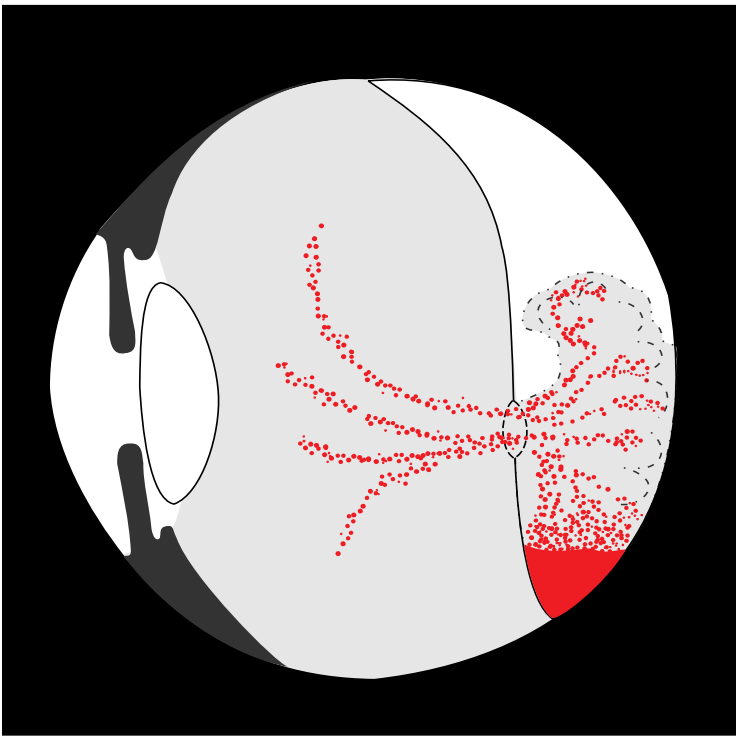

Fig. 3.**6** Sagittal section of the eye after several days of double patching with elevation of the patient's head. The blood cells have settled inferiorly in the retrohyaloidal space. However, double patching was not sustained, and vitreous membranelles have prolapsed through the holes in the posterior vitreous membrane and come into contact with the settled blood cells, which have subsequently obscured the view of the retina.

the blood is not confined in the inferior area. Then, were the eye to move, the blood would adhere to the vitreous membranelles (Fig. 3.**6**). As a result, the view to the fundus becomes obscured again, and double patching will no longer succeed in clearing the optic media, since the blood cells have become mixed within the vitreous gel. This is the rationale behind sustained double patching and elevation of the head.

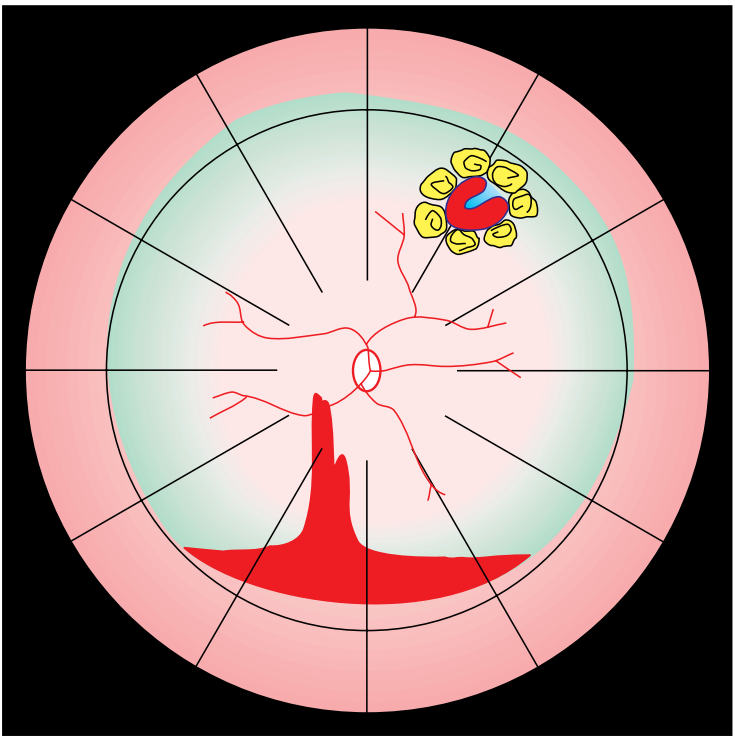

Fig. 3.**7** The blood in the retrohyaloidal space has settled inferiorly. To test whether it is clotted, the patient is placed in a supine position. As can be seen, the blood has not clotted, and it starts streaming toward the posterior pole within seconds. Double patching with elevation of the patient's head has to be continued. The cryopexy lesions around the horseshoe tear at 1 o'clock are pigmented, and the retina is attached.

In most instances (depending on the amount), the blood in the retrohyaloidal space clears within a few days or weeks. To test whether it is safe to remove the patches, the patient can be placed in the supine position. If the blood no longer rises toward the posterior pole, it indicates that the residual blood has clotted (Fig. 3.**7**). If this is not the situation, the patches will have to be kept on except for toilet, fundus examination, or laser treatment.

- Double patching and elevation of the patient's head have to continue until the retrohyaloidal blood is either absorbed or clotted. Wearing pinholes is of no benefit.

With pinholes, there are still enough eye movements to cause the blood to remix with fluid in the retrohyaloidal space, and it can then enter the vitreous if holes in the posterior hyaloidal membrane have developed.

- If no details of the fundus can be seen after double patching, because blood has already entered the vitreous gel, the patches should be removed. The patient can go about without restrictions,
  but only:
  1. If ultrasonography has confirmed that the retina is attached
  2. If regular examinations by ultrasonography confirm there is no detachment
  3. If the patient tests the visual field daily (having been shown how to do this).

In spite of the vitreous cloud, the patient can still perceive a circular visual field, tinted red. If the retina starts to detach, the patient will recognize a black shadow intruding on the visual field.

- The patient should be aware that a shadow progressively intruding into the visual field represents an emergency, i. e., a retinal detachment.

We would pursue this conservative regimen and wait for spontaneous clearing of the optic media for 3 or 4 months. If spontaneous clearing has still not taken place after that (or earlier, if the patient has only 1 eye), we would carry out a vitrectomy to clear the optic media. The results of a clinical study of this conservative regimen and its outcome are presented below.

3.4 Clinical Study and Results

The study included 100 consecutive patients with acute vitreous hemorrhage who underwent treatment with binocular occlusion and elevation of the head; the results were published in 1977 [3]. Among them were 43 eyes with hemorrhage of rhegmatogenous origin; in the remaining 57, the bleeding was due to hemorrhagic vasculopathy.

? What is the appropriate treatment for the 43 eyes with rhegmatogenous hemorrhage? Should a primary vitrectomy be performed?

▶ No. Instead, double patching with elevation of the patient's head led to clearing in 38 eyes: 20 of them in 1 day, 15 by 4 days, and 3 by the end of 1 week (Table 3.**1**).

Retinal tears were found in 25 of the 38 cleared eyes, in 16 eyes the tear was combined with a detachment. In 4 eyes, the hemorrhage had occurred due to a bridging vessel across a horseshoe tear that had been treated by a scleral buckle and cryopexy. No breaks were found in the remaining 9 eyes, and the hemorrhage was presumed to be due to pulling on a retinal vessel by the detaching vitreous.

Table 3.**1** Clearing time in 38 eyes with rhegmatogenous vitreous hemorrhage that responded to ocular immobilization.

Etiology	n	Time required for clearing (days)		
		1	2–4	5–7
Attached retinal tears	9	7	2	–
Tears with detachment	16	9	6	1
Bridging vessel on scleral buckle	4	2	1	1
Posterior hyaloidal detachment without retinal tear	9	2	6	1
Total	38	20	15	3

Double patching was abandoned in 5 of the 43 patients because the blood had already entered the vitreous gel and did not settle. Two of these eyes spontaneously cleared over several months without a retinal detachment developing, but in 3 eyes a detachment developed that was detected early by the patients during their daily visual field testing.

- Double patching was therefore unsuccessful in only 5 of 43 eyes with acute vitreous hemorrhage in clearing the view to the fundus. Retinal detachment occurred in only 3 of the total 43 eyes (7%), or in 3 of the 5 eyes that did not clear. However, this was immediately detected by the patient during daily testing of visual field.

For the few patients (1 in 9) in whom there is no spontaneous clearing, therefore, a decision can be taken in consultation with the patient about the best way of proceeding—either checking the retina with daily testing of the visual field and repeated ultrasonography, or carrying out a vitrectomy because of the probability that the retina will detach.

- **In 38 patients (88%), double patching led to clearing of the optic media, and details of the retina became visible. Once the optic media are clear, the appropriate treatment can be carried out for the following retinal findings:**
  1. If the edges of the break are attached and the optic media are sufficiently clear, laser treatment is preferable
  2. If the optic media are still somewhat hazy, cryopexy can be performed
  3. If a retinal detachment is found, it should be buckled, together with coagulation.

3.5 Summary

- Acute intraocular hemorrhage in the absence of a systemic vascular disease in the fellow eye is most likely to be due to a retinal tear, or tearing of a retinal vessel, during the episode of posterior vitreous detachment.
- Double patching with elevation of the patient's head results in settling of the blood in the retrohyaloidal space in 88% of patients (38 of 43). The blood takes from 1 day to 1 week to settle.
- Double patching has to be maintained until all of the blood is either absorbed or clotted. This can be tested by placing the patient in the supine position.
- **With this noninvasive management, a primary vitrectomy was avoided in more than 9 out of 10 patients with an acute rhegmatogenous vitreous hemorrhage.**
- Moreover, in a series of 100 patients with an idiopathic hemorrhage, it was found that **every other hemorrhage was due to a posterior vitreous detachment.**
- We therefore believe it is justifiable to regard every patient with an **acute vitreous hemorrhage as an emergency** requiring treatment by immediate double patching and elevation of the patient's head—**not** by sending the patient first for a diabetic or hypertensive study, causing delays in treatment.

? Why?

- Because the 2 other diagnostic probabilities—i.e., systemic vasculopathy or venous occlusion, can easily be excluded.

? How?

- By examining the patient's fellow eye and eliciting a history.

With this type of emergency management of idiopathic "vitreous" hemorrhage, the blood will still settle, and coagulation of a retinal break can be carried out without delay and without prior vitrectomy. Even if there is already some detachment, repair with buckling is an easy solution.

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4 Rhegmatogenous Retinal Detachment “without” a Break

A retinal detachment in which a break is not found is a problem.

? What should be done?

▶ First of all, confirm that you are dealing with a rhegmatogenous detachment.

4.1 Characteristics of a Rhegmatogenous Retinal Detachment

● **The characteristics are:**

1. It is *symptomatic:*
   The patient reports sudden flashes, black spots, or a shadow obscuring part of his or her field of view
2. It has *typical features:*
   The rhegmatogenous detachment has **convex surfaces** and **convex borders** and will, when it is developed, extend from **ora to disk**.

First, recall:

The differential diagnosis of an inferior detachment that rises equally on both sides of 6 o'clock:

▶ **An exudative detachment without a hole**
In this instance, if the patient lies flat, the fluid will ascend symmetrically toward the posterior pole, or symmetrically to either side when the patient's head is turned to either side;
the change of contours is symmetrical.

▶ **A rhegmatogenous “inferior” detachment that is bullous and symmetrical**
In this instance, if the patient lies flat and the head is turned to either side, it will be found that
the change of contours is asymmetrical,
i.e., only 1 border of the detachment will rise, and it will indicate the side of the primary break. This shows that in reality we are confronted with a superior temporal or nasal detachment. Here it should be recalled that the primary break in this type of detachment lies within $1^1/_2$ clock hours beneath the higher border of the detachment (see Chapter 2.2, p. 13).

- **A rhegmatogenous inferior detachment that is not bullous, but symmetrical**
  If this patient lies flat on a stretcher and the head is turned to either side, there is
  no change of contours.
  Here we are confronted with an inferior detachment, with a hole exactly at 6 o'clock.

4.2 Optical Problems in the Search for the Retinal Break

We can now focus on how to find the retinal break in a detachment that is apparently without a break. Several problems are faced when this happens.

4.2.1 Hazy Media

Vitreous hemorrhage may be found, and what has to be done here is discussed above (see Chapter 3, p. 27). The patient is examined at the slit lamp, and it is found that the vitreous gel is free of cells and the blood is only in the retrohyaloidal space. The patient should immediately be double patched, with elevation of the head. The blood will settle down, the patient will see better, and as the view to the retina clears, it may become possible to detect the break. Another alternative is that inflammatory cells may be found within the vitreous. But this occurs more gradually than a hemorrhage, and must be treated depending on the etiology.

If the patient reports a sudden loss of vision with a shadow intruding on the visual field, then there will probably be a retinal detachment behind the haze.

4.2.2 Pupillary Obstruction

An opaque posterior capsule may be found, requiring Nd:YAG (neodymium–yttrium aluminium garnet) laser application to open or enlarge the pupil (Fig. 4.**1**). Alternatively, there may be an astigmatism from the edges of an intraocular lens. This can be overcome using the special contact lenses discussed below (see pp. 45 and 46).

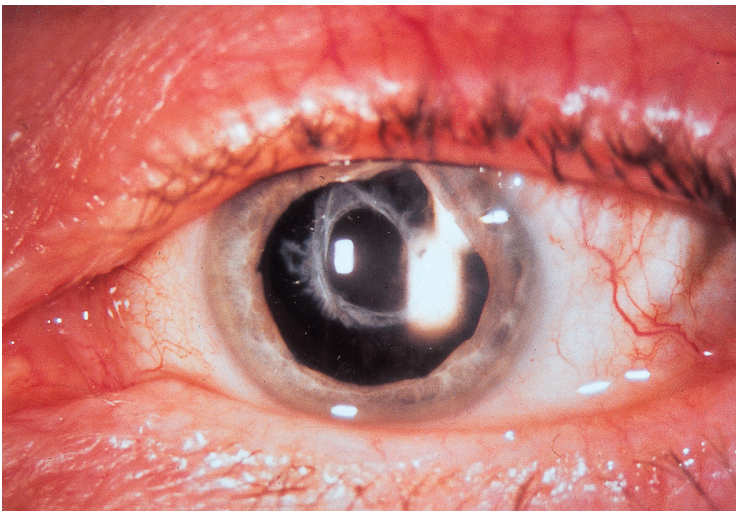

Fig. 4.**1** Pupillary obstruction by a secondary cataract (Photo courtesy of H. Lincoff, M. D.). **a** The opaque posterior capsule is obscuring the view to the retina.

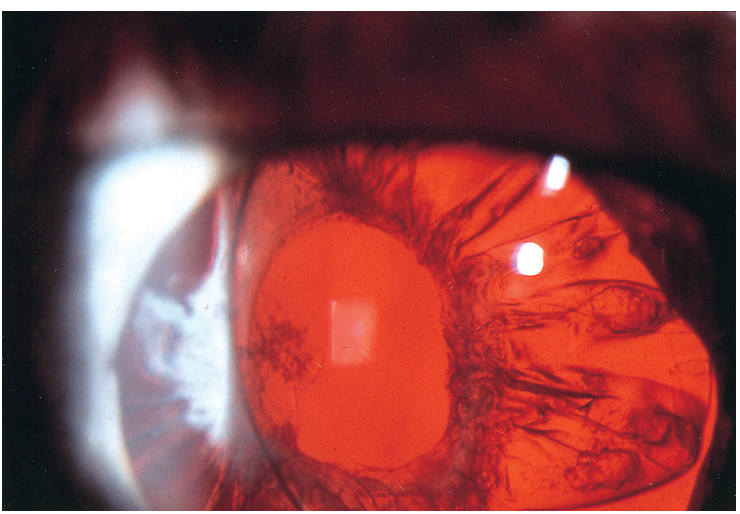

Fig. 4.**1 b** Posterior capsule after cataract operation is clearly outlined by retrograde illumination.

4.3 Techniques for Finding a Tiny Break

4.3.1 Define the Borders of the Retinal Detachment

After the borders of the detachment have been determined, follow the 95% Rules [1, 2], which define the area in which the primary break is most likely to be found. For this purpose, the patient lies flat on a stretcher and the head is tilted to either side, so that the detachment can be assigned to 1 of the 3 types. The details of the 4 Rules, how to find the primary break, discussed above should be recalled (see Chapter 2.2, p. 13).

4.3.2 Use Special Magnification

The break must be tiny, as it would otherwise already have been found. The binocular biomicroscope should therefore be used, and the slit beam with maximum illumination. For a phakic or aphakic eye, the direct 3-mirror Goldmann contact lens [3] is still the lens of choice for detecting the break.

? But what is the best choice in an eye with a less than optimum pupil (4 mm in diameter), or with an intraocular lens?

- The periphery of this type of eye should be examined using indirect techniques.
- Those available include:
  - Biconvex +78 dpt or +90 dpt lens
  - Mainster and Volk indirect wide-field contact lenses [4]

The Mainster lens has a field of 125°, the QuadrAspheric lens (Volk) has a field of 130°, and the new Equator Plus Scanning Fundus lens (Volk), developed by Lincoff for small pupils, has a field of 140° and is even suitable for pupils as small as 3 mm (Fig. 4.**2**). With these indirect contact lenses, it is best to use a short beam. Admittedly, a certain amount of experience is needed to become expert in the use of indirect contact lenses. To visualize the periphery, the patient's eye has to be rotated slightly and the contact lens slightly tilted, and with simultaneous depression the ora can usually be made visible in a pseudophakic eye with a pupil 3–4 mm in diameter. It should be

Fig. 4.2 Indirect wide-field contact lenses by Mainster (left) and Volk: QuadrAspheric (middle), Equator Plus Scanning Fundus lens for small pupil, developed by Lincoff (right).

borne in mind, however, that scleral depression of the periphery is essential with both the direct and indirect contact lens systems in order to detect a tiny break in the periphery.

? What should be done if the break can still not be found after repeated and meticulous examinations?

4.4 Intraoperative Techniques for Finding a Tiny Break

After the conjunctiva and Tenon’s capsule have been opened over the suspected quadrant, the search for the break can start, but the options available should be applied systematically and step by step.

4.4.1 Re-study the Retinal Periphery with Depression

Since the eye has been anesthetized, the examination is easier. Study the eye in the quadrant of probability, with depression, and mark the latitude of **the line of the anterior insertion of the hyaloidal membrane**. Most likely the break or breaks will be on this, or close to it. Search for any tit or other irregularities along this line, as these often harbor the break.

4.4.2 Diagnostic Freezing at Special Points

Diagnostic freezing can be carried out in these suspicious areas, limited to special points.

- Never become obsessed with the idea that the break can be found by freezing—above all, the entire line of the hyaloidal insertion should not be frozen. Never overfreeze!

At this point, one should be aware of the damage that can be inflicted on the retina and the vitreous, which can even provoke proliferative vitreoretinopathy.
For a diagnostic freeze, select a medium cryopexy lesion, the dosage of which is discussed in Chapter 7, p. 93.

4.4.3 Diagnostic Balloon in the Area of Suspicion

If a suspicious tit is found in the 95% area of probability, but the diagnostic freeze is equivocal, a parabulbar balloon can be inserted beneath the tit without drainage of subretinal fluid, creating a temporary buckle (see Part 2: Chapter 9. Temporary Balloon Buckle without Drainage), and the patient should be seen again after 1 day. If the tit concealed a retinal break, the next day the fluid will have disappeared, and the patient will be happy to have regained the lost visual field. However, the break now has to be secured using laser applications.
In this instance, a diagnostic balloon without scleral sutures is less traumatic than a diagnostic segmental buckle, which has to be sutured onto sclera.

? **If promising irregularities in the area of probability along the insertion of the anterior hyaloidal membrane are not found, then what should be done?**

▶ Think the retinal findings over again.

Above all, you should not move on to extensive prospective surgery merely because a *solution has not yet been found by you.*

? What rational and minimally invasive alternatives might there be?

▶ Various options will be discussed below.

4.4.4 Prospective Segmental Buckling

Carrying out prospective segmental buckling implies that only the extent of the area of probability should be buckled, since the primary break is localized there 95% of the time.

▶ **Extent of prospective segmental buckle**

- For a superior temporal or nasal detachment, **buckle the upper 1 1/2 clock hours** (Fig. 4.**3**).
- With a superior detachment that crosses the 12 o’clock radian, buckle 1 1/2 hours on either side of 12 o’clock, i.e., **buckle 3 clock hours** (Fig. 4.**4**).
- With an inferior detachment, **buckle up to 3 clock hours** beneath the higher border of the detachment to 6 o’clock (Fig. 4.**5**).

▶ **Latitude of prospective segmental buckle**

- **When the insertion of the anterior hyaloidal membrane can be identified:**
  - In this type of detachment, the prospective segmental buckle should be placed at the **line of insertion of the anterior hyaloidal membrane.**
  - What size of sponge should be selected?
    You might use the 3 x 5 mm oval sponge, held in place with mattress sutures 7 mm wide. This will buckle an undetected break that might be 3 mm anterior or posterior to the line of the insertion of the anterior hyaloidal membrane.

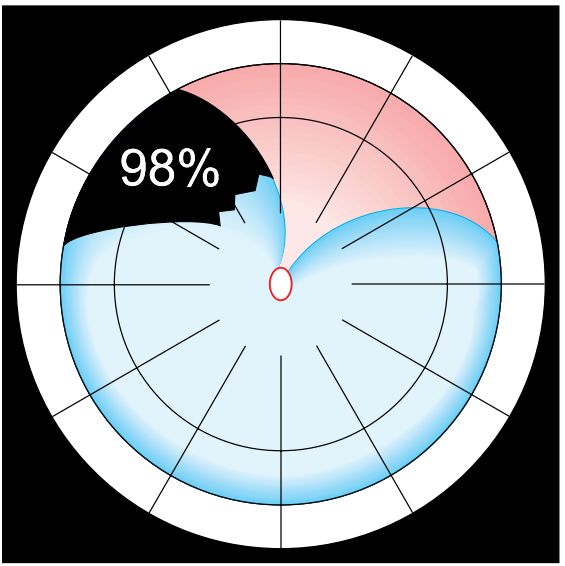

Fig. 4.3 a **Rule 1.** In a superior temporal or nasal detachment, the primary break will lie within 1 1/2 clock hours beneath the higher border in 98%.

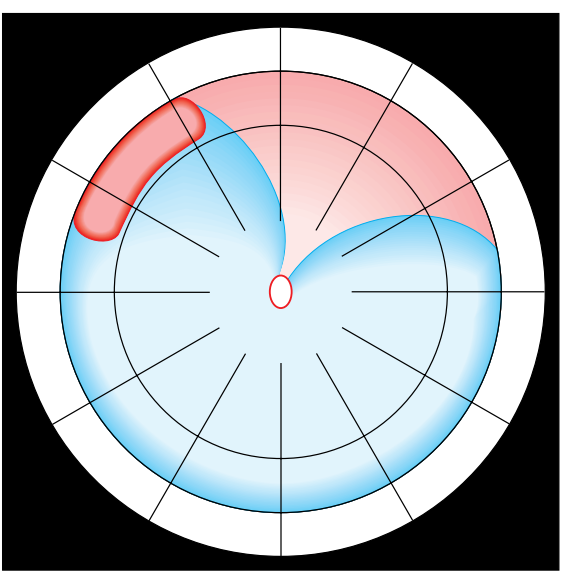

Fig. 4.3 b Extent of prospective segmental buckle. In a superior temporal or nasal detachment in which a primary hole cannot be found, the buckle will extend 1 1/2 clock hours beneath the higher border, covering the 98% area of probability for a hole. After reattachment the buckle can be lasered.

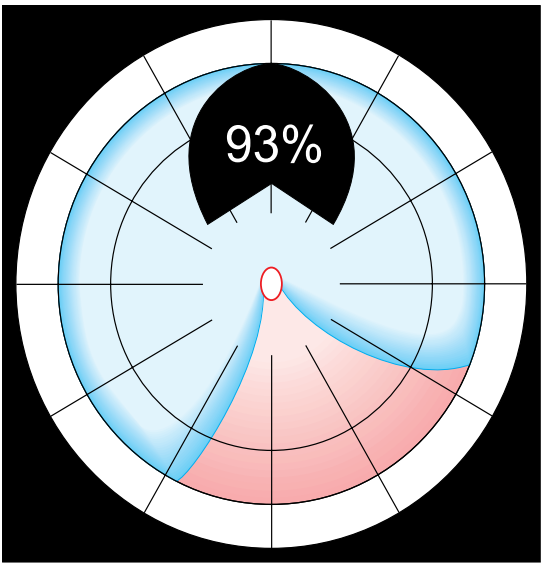

Fig. 4.4 a **Rule 2.** In a total or superior detachment that crosses the 12 o’clock meridian, the localization of the primary break is 1 1/2 clock hours to either side of 12 o’clock in 93%.

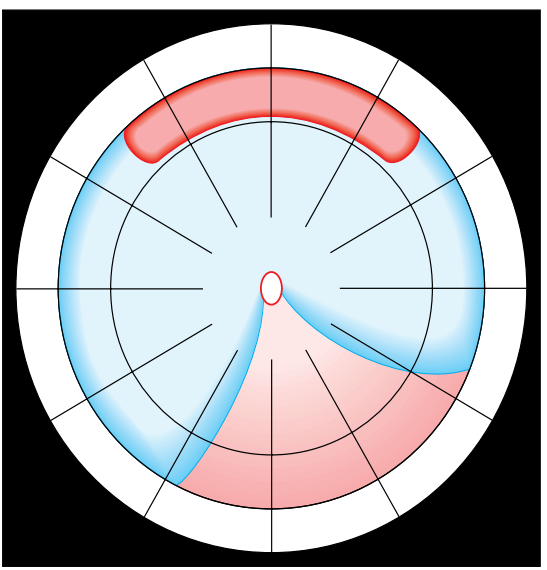

Fig. 4.4 b Extent of prospective segmental buckle. In a total detachment in which a primary hole cannot be found, the buckle will extend from 10:30 over 12 o’clock to 1:30. After reattachment the buckle can be lasered.

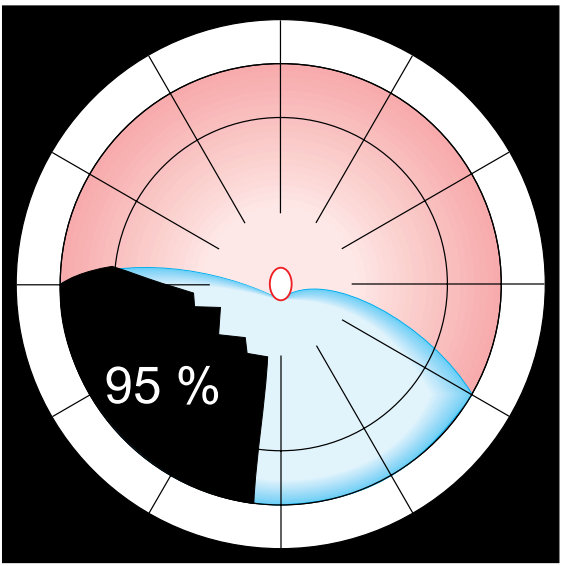

Fig. 4.5 a **Rule 3.** In an inferior detachment, the higher side indicates the side of the disk on which the primary break is located in 95%.

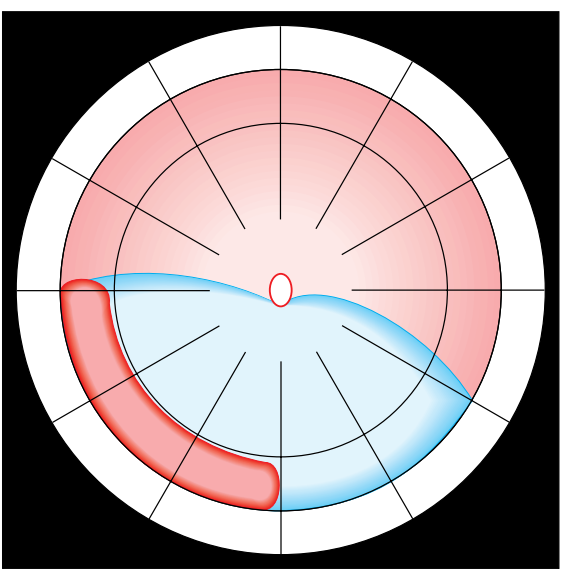

Fig. 4.5 b Extent of prospective segmental buckle. In an inferior detachment in which the primary break cannot be found, the buckle will extend from the higher side of the detachment to 6 o'clock. After reattachment the buckle can be lasered.

- **When the insertion of the anterior hyaloidal membrane can*not* be identified:**
  - if there is a **phakic detachment, the break is most probably 13 mm from the limbus**, and the segmental buckle should be centered there.
  - If there is an **aphakic or pseudophakic detachment, the break is most probably 12 mm from the limbus,** and the segmental buckle should be centered at that distance.

These points are emphasized here because it was taught for many years that aphakic eyes should be encircled, because they harbor multiple tiny holes in the entire periphery that cannot be seen. This proved to be incorrect [5], probably because tiny holes could not be detected before the introduction of biomicroscopy. In addition direct and indirect contact lenses were not yet available for the meticulous preoperative searching with the biomicroscope that is necessary to find these tiny breaks.

▶ Size (diameter) of prospective segmental buckle

- **Size of sponge cylinder to be selected when the insertion of the anterior hyaloidal membrane is *not* known:**
  - You can also apply a 3 x 5 mm circumferential buckle, but in this instance it should be centered at the preferred latitude of location of the break, i.e., at 13 mm from the limbus (phakic) or 12 mm (aphakic or pseudophakic) from the limbus—the latitude that has the best chance of harboring the undetected break.

If the retina reattaches the next day, then the break was buckled.

- It should not be forgotten that interrupted laser lesions must be applied over the entire length of the prospective segmental buckle. This is to secure the tamponaded, but “undetected” break or breaks on it.

? What should be done if the retina fails to reattach after prospective segmental buckling?

▶ The retina should be studied using the biomicroscope and the various contact lenses once again. What you have learned from the unsuccessful surgery is that the area buckled probably does not contain the break, or all of the breaks.

? If the break can still not be found, what should be done?

▶
- Arbitrarily extending the segmental buckle over the circumferential length is not a good solution.
- Also, do not perform an arbitrary cerclage; this is no better solution.

? Why?

▶ **For the following reasons:**
- If the periphery is re-studied with the biomicroscope and with various lenses with simultaneous depression instead, there is a better chance of finding the break, and it is already known where the break is *not* to be found.
- In addition, a cerclage unnecessarily compromises the vascular integrity of the eye, as demonstrated by recent studies with Doppler sonography and angiography [6–10].
- The other surgical alternatives available when prospective segmental buckling has failed are using a diagnostic expanding gas bubble, or a vitrectomy in conjunction with heavy perfluorocarbon liquids.

4.4.5 Diagnostic Expanding Gas Bubble (Descending or Ascending)

When the patient is in the vertical position, an expanding intraocular gas bubble will descend to the level at which the retina below the bubble will reattach, indicating the level of the break [11]. More details about the expanding gases used are given later (see Part 2: Chapter 10. Temporary Gas Tamponade without Drainage: Minimal Intraocular Surgery for Retinal Detachments).

Figure 4.**6** shows how to proceed. The detachment here is from 2 o’clock through 6 to 10 o’clock, in the presence of a cerclage and a radial buckle at 10 o’clock. A small amount of an expanding gas is injected through the pars plana. C_2F_6 or C_3F_8 can be suggested, which will expand 3.3 or 4.0 times the injected volume. The patient is asked to keep the head in a vertical position, elevated during the night to about 45°.

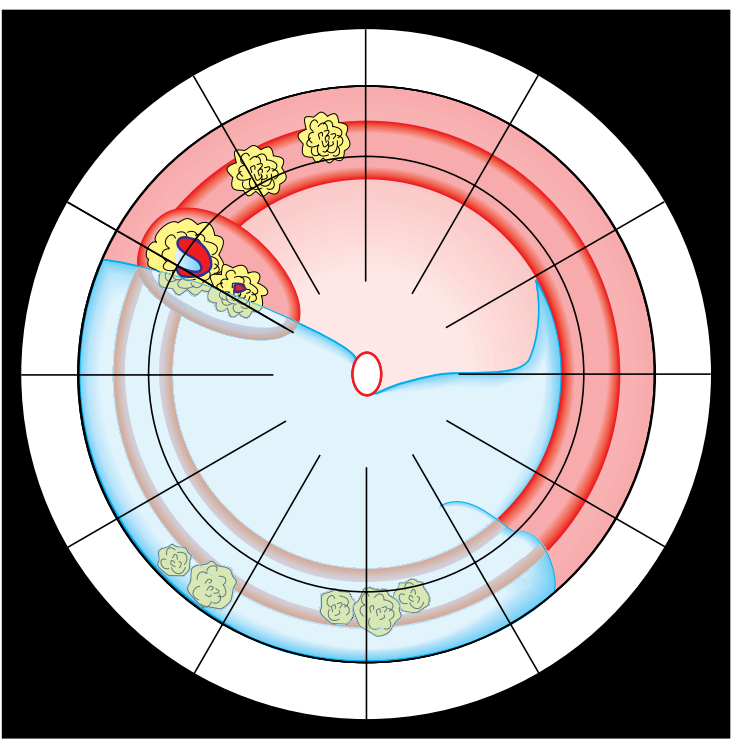

Fig. 4.**6** The use of a diagnostic expanding gas bubble (descending or ascending) to find a break in a detachment (findings documented by H. Lincoff, M. D.). **a** Detachment from 2 o’clock through 6 to 10 o’clock after a cerclage, drainage, radial buckle at 10 o’clock, and coagulation in various areas. Another break could not be detected.

- Initially, the descending expanding gas bubble will be observed. At the moment when its meniscus crosses the horizontal meridian of the break, the subretinal fluid inferior to it will become absorbed.
  The patient will report good news:
  — Parts of the visual field will have come back.

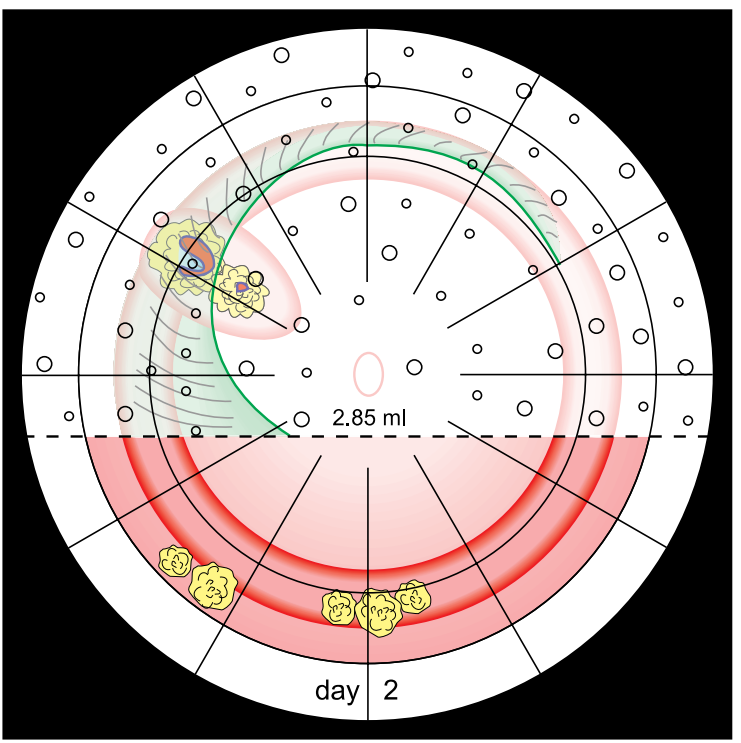

Fig. 4.**6 b** To detect a break, an expanding gas (0.9 ml of C_2F_6) was injected into the vitreous. Over 2 days, it expanded to 2.85 ml. The patient slept in an elevated position (45°), and was able to walk around during the day. When the gas bubble crossed the 10 o'clock meridian, the retina suddenly reattached. The gas bubble made a vitreous traction line visible, and leakage from the horseshoe tear was suspected.

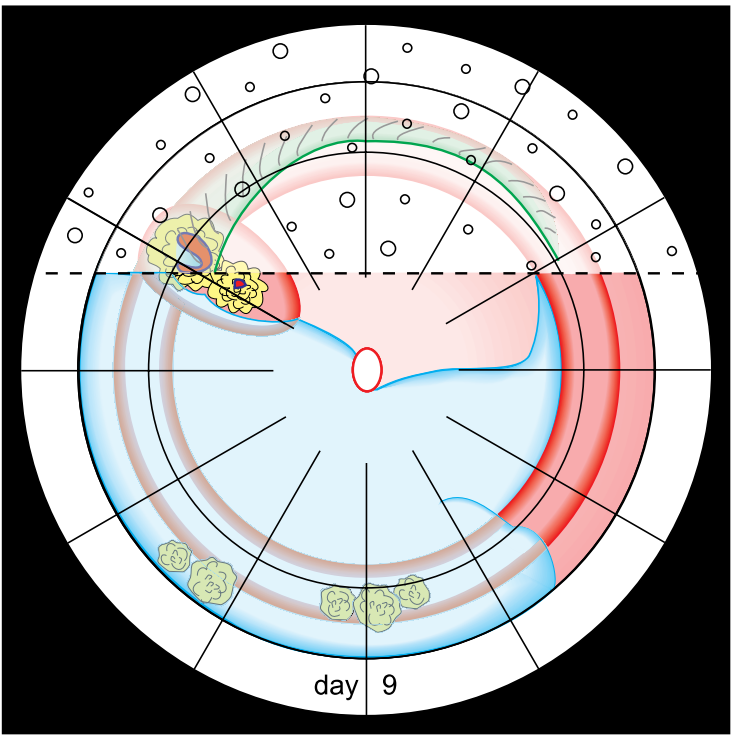

Fig. 4.6 c During the next few days, the gas bubble receded, and the meniscus ascended. When it crossed the 10 o’clock meridian, the patient suddenly reported a loss of superior visual field; the retina had again become detached. The leakage at the horseshoe tear was confirmed, and could now be treated.

? What does this imply?

▶ It demonstrates the level of the break, which must be localized either on the temporal or nasal side of the meniscus, probably anterior to the equator. This area can now be re-studied with depression in order to detect the break.

If the break is still not found, then after a few days the bubble will decrease in size and ascend. Now you have to wait for the moment

when the ascending meniscus approaches the known meridian of the break.

- This provides important information, because when the meniscus of the ascending bubble crosses the break and goes above it,
  The patient will suddenly report bad news:
  - The superior field has gone again.

And when the fundus is examined, it will be found that the inferior retina has detached again. It is now certain which level has to be investigated to localize the break. Knowing the exact level helps in the search. However, it is still ***up to you to detect the break*** by meticulous study, using depression. It should be remembered that the hole will be a tiny one, located either in the temporal or nasal periphery.

- **If the break is detected, it can be surrounded with laser lesions:**
  - The intraocular gas bubble can be used to tamponade it subsequently (the patient should be asked to tilt the head forward to provide adequate tamponade for the break, or the bubble can be enlarged by another gas injection).
  - Alternatively, a temporary balloon can be inserted on top of the radial buckle (to augment its indentation and provide adequate tamponade for the leaking break).
  - Alternatively, a short sponge can be sutured onto sclera to support the leaking break.

It should be remembered however, that if the retina is reattached after the gas tamponade or buckling, it must be ensured that the area of the break is sealed off again sufficiently with laser lesions.

? What should be done if the retina detaches once again after the gas bubble has disappeared completely?

▶ This means either that the break was not found, or that not all of the breaks were found.

Again, first of all the eye should be re-studied for the presence of a hole. If you are again not successful, you may need to recognize your limitations and send the patient to someone with greater expertise.

Here a last surgical resort for this type of detachment “without” a break after the entire spectrum of diagnostic procedures and alternatives with minimal surgery has been attempted. The subsequent surgery should be carried out by an expert in vitreous surgery.

4.4.6 Vitrectomy in Conjunction with Heavy Perfluorocarbon Liquids

With this technique, the first step is to try to release tractions that may be present, and then the posterior eye is filled with heavy perfluorocarbon liquids [12] to detect the break using what is known as the “schlieren” phenomenon. This sounds logical, but in clinical practice it rarely succeeds, because the source of the schlieren for tiny breaks is not discernible.

As a very last resort, the use of a silicone oil tamponade might be considered after the vitrectomy. However, one should be aware of all the secondary complications that will develop.

- At this point, it should also be borne in mind that a vitrectomy without silicone oil injection, even in the hands of an expert, already harbors many secondary complications, such as the development of proliferative vitreoretinopathy (PVR) at present ranging in frequency between 8% and 20% and new breaks with a frequency of between 5% and 15% – resulting in a high rate of redetachments – and the development of a secondary cataract [13–16].

An effort should therefore be made to circumvent this last option by all means, since at present it still harbors many short-term and long-term complications.

Let us return now to the clinical situation.

? How often is the break not found in a rhegmatogenous retinal detachment?

- According to various authors, the break will not be found in between 1% and 5% of patients, a small proportion of all the detachments seen.

Admittedly, in a pseudophakic detachment it is harder to detect the tiny break. However, using the new indirect wide-field contact lenses for a small pupil, as recommended by Lincoff [17], and combined with simultaneous depression, it is almost always possible to detect even tiny breaks.

4.5 Summary

When confronted with an eye in which the break has not been found after a meticulous and repeated search, a rational approach should be adopted to solve the problem.

- After the borders of the detachment have been defined, first study the retinal periphery with depression in the area of probability; according to the Rules, a hole should be found here in 95%.
- If a break is not found in this area, re-study the area again with depression during surgery, define the insertion of the anterior hyaloidal membrane, and use point freezing to detect the break in suspicious areas.
- If a break is still not found in the suspicious area, insert a diagnostic parabulbar balloon in the area.
- If a suspicious area is still not found, apply prospective segmental buckling and limit it to the area of probability. Place the buckle either at the insertion of the anterior hyaloidal membrane, or—depending on the state of the lens—at 13 mm or 12 mm from the limbus.
- As another possibility, a diagnostic expanding gas bubble can be used to detect the meridian of the break.
- Never move on to maximal extraocular or intraocular surgery merely because the problem has not yet been solved by you.
- Instead, keep things in perspective and bear in mind that the break should be detected after a meticulous search except in 1%–5% of detachments.

- When you are confronted with a **difficult detachment, try to divide the treatment into small procedures:**
  - It is worth recalling here Descartes’ axiom that if you have a complex problem which you cannot solve, first divide it into small problems that are easier to solve. This not only provides a more rational approach to a difficult detachment, but—since it involves smaller procedures—is also a more favorable approach, in terms of the long-term prognosis, to the eye being treated.

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5 Differential Diagnosis: Rhegmatogenous versus Nonrhegmatogenous Retinal Detachments

We can begin by recalling

The characteristics of rhegmatogenous retinal detachments:
1. They have convex borders and surfaces
2. They develop dependent shapes in relation to the position of the most superior retinal break
3. They extend from ora to disk
4. They are progressive.

Detachments caused by superior breaks become bullous, and progress rapidly in a dependent direction. Detachments caused by inferior breaks are not bullous, progress slowly, and can develop pigment demarcation lines at levels of prolonged arrest.

By contrast

Nonrhegmatogenous retinal detachments:
1. Tend to be confined
2. Do not extend from ora to disk.

Lincoff and Kreissig [1] have divided these into 3 categories:
- Peripheral
- Central
- Dependent

5.1 Peripheral Retinal Elevations

5.1.1 Cystoid Degeneration

Figure 5.**1** shows a peripheral retinal elevation. It is easily recognized as cystoid degeneration. Why? Because cystoid elevations can be seen in the far periphery of almost every adult patient. The elevation has irregularly shaped borders; some areas are convex, and others concave. The question that might arise is: Does a convex area with “holes” possibly represent the beginning of a retinal detachment? Look at the 2 round holes at 1:15 in Figure 5.**1.** Does this mean that the patient will develop a rhegmatogenous retinal detachment during the following days or weeks?

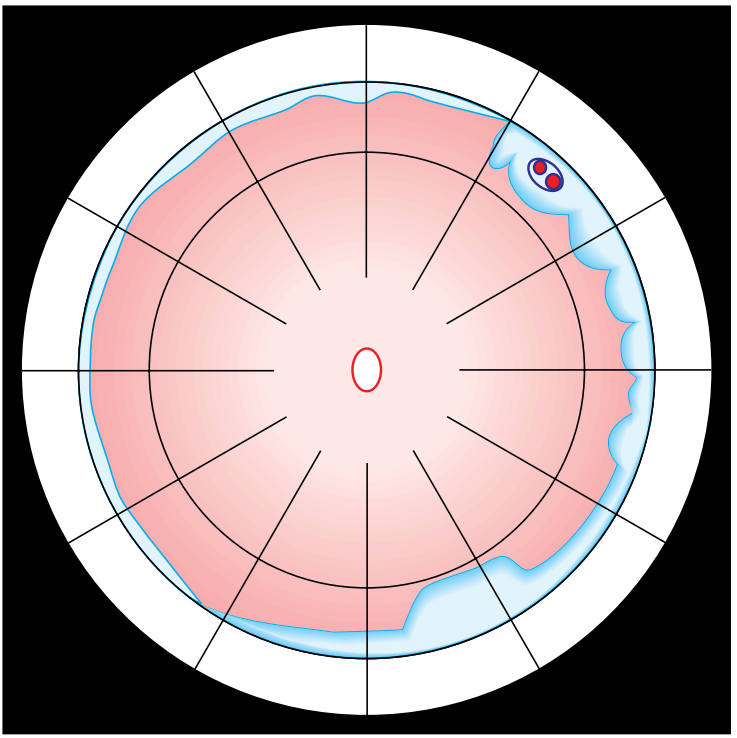

Fig. 5.1 Peripheral cystoid degeneration, with an irregular posterior convex and occasionally concave border. The 2 holes at 1:15 are in the inner layer of the schisis-like degeneration.

? If so, will this retinal elevation progress in a dependent direction and toward the disk, in the way that a rhegmatogenous detachment does?

▶ The odds are that it will not progress.

? Why?

▶ Because these small holes are in a line of peripheral cystoid degeneration, so that they are only in the internal layers of the retina.

Consequently, no treatment is required. Of course, the patient had no symptoms in this instance, and these findings were discovered in the course of a thorough examination.

However, if there are still doubts about the diagnosis of cystoid degeneration, the patient can be told how to test the visual field, and can be asked to return in a week's time. If the convex elevation with holes has not advanced after a week and the diagnosis is still doubtful, ask the patient to come back in 3 months. If the elevation has not progressed after 3 months, it is very unlikely that the convexity with holes represents a slowly progressing rhegmatogenous detachment.

? What would you expect if it were a detachment?

▶ Remember to look for pigment demarcation lines in stationary detachments. If, after 3 months, you do not see any pigment demarcation lines, you can reassure the patient that the holes are not full-thickness, but are limited to the internal retinal layers of cystoid.

However, it may still be unclear what to do in a patient with cystoid degeneration when a flap tear is seen.

? Is this a problem or not?

▶ **It is not,** because if a patient is going to develop a flap tear, the best scenario for the patient is to have it within cystoid peripheral degeneration, since it will then only represent a tear in the internal retinal layers, and will not cause a detachment.

▶ **Consequently, a horseshoe tear, as well as a round hole in cystoid peripheral degeneration, do not need to be treated.**

5.1.2 Degenerative Retinoschisis

Figure 5.**2** shows an example of more extensive cystic degeneration, representing a degenerative retinoschisis. Normally, a retinoschisis does not have a hole.

● Retinoschisis characteristically has an unbroken, often circular shape, and it may be bullous.

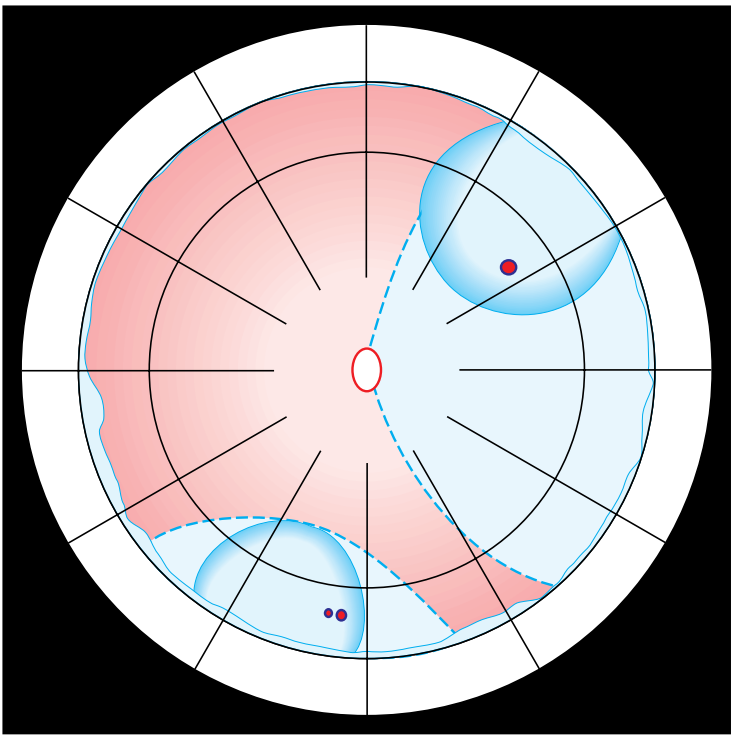

Fig. 5.2 Peripheral degenerative retinoschisis: There are 2 circular retinal cysts (from 1 o'clock to 2 o'clock and from 6 o'clock to 7:30), with holes in the internal layer. The broken line indicates the change in contour that would be expected to develop if an **additional break in the external layer,** most of the time located at the posterior margin of the cyst, were to occur and cause an accompanying detachment.

A circular shape is never found in a rhegmatogenous detachment. A detachment would be more dependent in relation to a break, and therefore asymmetrical. The retina here has a schisis separation, and appears thin. In an old detachment, it might also look thin, but it would then also have pigment demarcation lines.

- Retinoschisis elevations do not move when the patient is looking up or down, and do not progress dependently or toward the disk.

When laser scotometry is applied in a retinoschisis, a scotoma is found, and if the retinoschisis is more extensive, a peripheral scotoma is found in the visual field. However, the patient with a retinal schisis is also asymptomatic, and the schisis is usually found during routine examinations. Retinoschisis is located in the superior or inferior temporal quadrants, or both, and the finding is frequently present in the fellow eye.

- In summary, a **retinoschisis** generally tends to be round, and the inner layer of the cavity tends to be thin; it remains stationary, and does not develop a pigment demarcation line.

If there is a doubtful elevation without a pigment demarcation line, a wait-and-see approach can be taken, and if a pigment demarcation line has not developed after a number of months, this confirms that retinoschisis is present. Observation should continue, and treatment should not be given. Only in rare and exceptional instances does the retinoschisis progress toward the posterior pole. Instead, it remains stationary for decades, and the patient has no symptoms.

The differential diagnosis of a retinoschisis becomes a problem when the schisis becomes very extensive. It should be remembered that retinal schisis cysts tend to be circular. They have a typical tenseness, no folds, and do not shift in relation to movements of the patient's head.

- **Even if a hole develops in the *internal layer*, the shape of a retinoschisis does *not* change;**
  the shape may not relate to the position of the break.

Consequently, another look at the position of the break in Figure 5.**2** will show that it is in the "wrong" position for a break in a rhegmatogenous detachment.

- Only when **retinal schisis cysts develop holes in their *external layers*, which tend to occur at the posterior margin of the cyst, does the contour change,** depending on the position of the break in the external layer, which controls the additional rhegmatogenous detachment.
  This change from a retinal schisis to a rhegmatogenous retinal detachment may be sudden and symptomatic.

When superior retinal cysts have a hole in the outer layers, they develop a progressive dependent detachment that causes a sudden loss of visual field. However, holes in the external layers of an inferior retinoschisis only cause a slowly progressing detachment, which is often not recognized by the patient and which may therefore develop successive pigmentation lines, indicating its slow progression.

5.1.3 Edema

This represents a peculiar type of detachment (Fig. 5.**3**). It is peripheral in location, and it does not have convex contours or progression

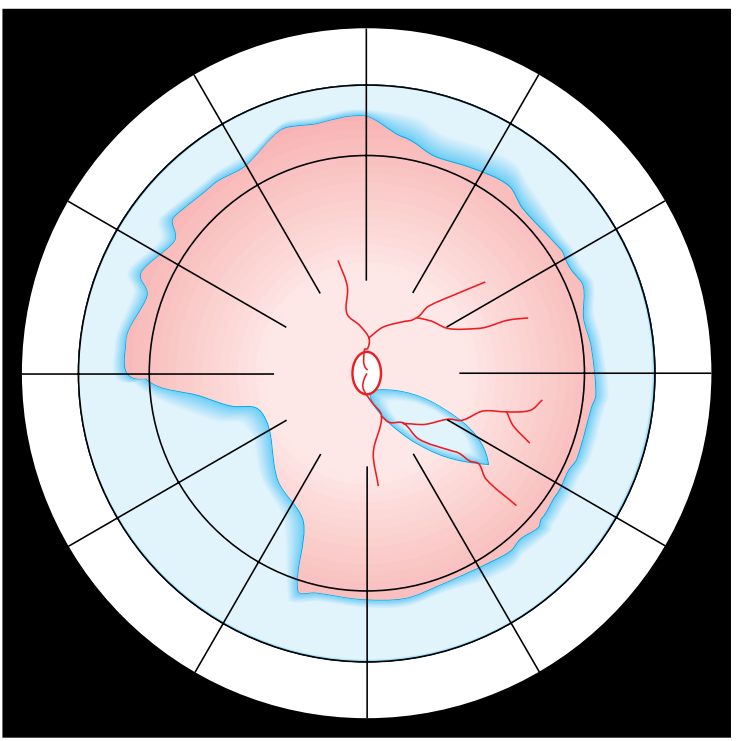

Fig. 5.**3** Peripheral edema. Circumferential edema in the periphery after blunt trauma to the globe. There is a localized pocket of fluid along the infero-temporal vessels.

in a dependent direction, in the way that a rhegmatogenous detachment does. A rhegmatogenous retinal detachment would never extend around the periphery without progressing toward the center and to the disk. It should be remembered that a rhegmatogenous detachment due to a hole would have a certain degree of elevation, consistent with its large extent.

● In Figure 5.**3**, however, the superior and **extensive elevation is relatively shallow,** and it is **not progressing** dependently or **toward the disk.**
Consequently, it cannot be a rhegmatogenous detachment.

If any parts of the contours of this retinal elevation are analyzed, it can be seen that it does not resemble any of the retinal elevations or rhegmatogenous detachments so far discussed. The shape of these peripheral elevations alone allows one to conclude that this is not an example of rhegmatogenous retinal detachment. A search for a hole is not necessary, and surgery should not be carried out, as it will not benefit the patient.

? What does the patient have?

▶ – If the patient had been asked to begin with about the history and how the symptoms developed, he or she would have described receiving a blow to the eye.
– The condition is one of peripheral edema, with a shallow detachment of the sensory retina as a result of blunt trauma.

Edema may be confined to the area of contusion, but can also extend, as in this patient, all the way around the eye. There may even be isolated pockets of fluid centrally along a vessel.

● Typical of this traumatic peripheral edema or shallow detachment is that, as in cystoid degeneration, its **posterior borders are irregular** and occasionally concave and that it even might have **lamellar holes.**
This flat retinal detachment due to trauma will not progress, but will finally regress.

It should therefore be observed, and there will be a gradual absorption of the fluid over days. Support can be provided for the regression of the edema using systemic corticosteroids.

5.2 Central Elevations

Retinal elevations due to central serous retinopathy or age-related macular degenerations will not be discussed here, since these are usually limited to the posterior pole and it can be easily ascertained by biomicroscopy that there are no retinal breaks. They are therefore not confused with rhegmatogenous retinal detachments.

5.2.1 Macular Full-Thickness versus Lamellar Hole

The stages of a macular "hole" and possible treatment modalities will not be discussed here. The problem concerning us here is that of a macular cyst with a hole, confronting the surgeon with the question of whether this is only a hole in the inner layers of the retina or a full-thickness hole, i. e., whether there is an **early rhegmatogenous detachment that requires immediate treatment** (Fig. 5.**4**).

The correct diagnosis is essential here, although it is sometimes difficult to reach. Otherwise, an additional loss of central vision would be entailed in treating this type of patient using an intraocular gas bubble and macular photocoagulation or even buckling, on the assumption that it is a full-thickness hole.

The problem is to differentiate between a central macular elevation with a lamellar hole and a full-thickness hole accompanied by a dependently progressing retinal detachment. However, a primary hole in the macula causing a retinal detachment rarely occurs; that could be only a paracentral hole, and would then be most likely to be found in a myopic eye.

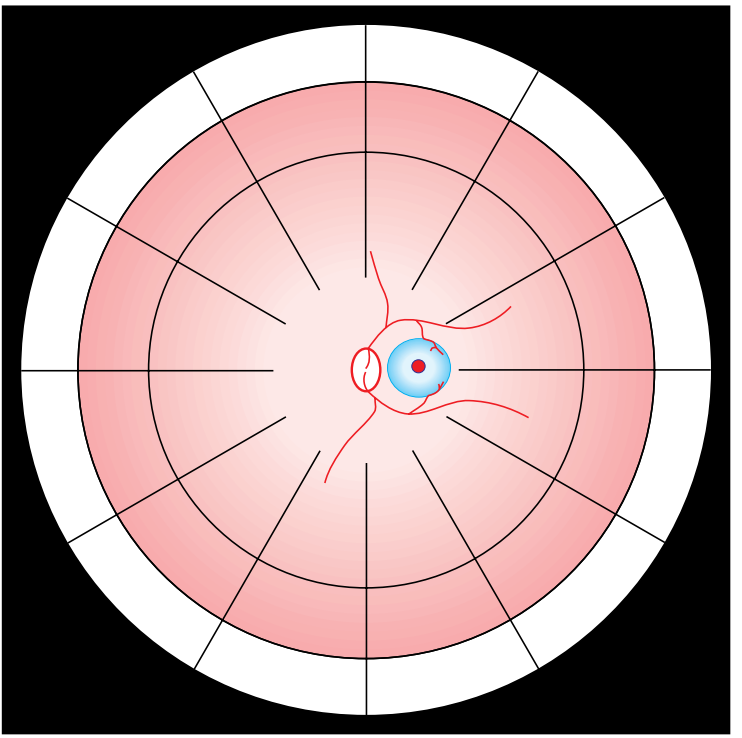

Fig. 5.4 Macular cyst with a "hole." The symmetry around this hole suggests that the hole lies only in the internal layer of the retina. During the long-term follow-up, the non-dependent progression and the non-development of a pigment demarcation line confirmed the diagnosis of a lamellar hole.

? What are the characteristics that differentiate between a macular cyst with a lamellar hole and a full-thickness hole?

▶ What is unique about this macular cyst, a finding that is often seen, is that:
- The elevation is symmetrical to the hole, i. e., the retina is equally elevated above and below
- The elevation is not dependent in shape
- Will not progress dependently
- It will never develop pigment demarcation lines.

In 2 series, each including 1 000 detachments, of patients who underwent surgery in New York [2] and in Tuebingen [3], there was only 1 detachment in which the primary hole was close to the fovea, i.e., paracentral, and the patient concerned was a myope.

- However, when **a "hole" in the macula is seen in an old detachment** extending from disk to ora, and an anterior hole is not found, the **idea of a macular hole should be dismissed** (for certain in a Caucasian population), and instead another search should be made for a break in the periphery.

In all detachments with a so-called "hole" in the macula, this proved to be a secondary or degenerative hole, ascertained by retinal reattachment obtained by limiting the buckling to the hole in the periphery without drainage. After reattachment of the retina, these macular "holes" are often no longer visible.

- An additional factor that warrants caution in making the wrong diagnosis of a primary macular hole causing a rhegmatogenous retinal detachment is the fact that **in old detachments, there is very unlikely an additional macular "hole" that is full-thickness, but rather only a lamellar hole.**

5.2.2 Ischemic Edema

The retinal elevation in Figure 5.**5** has a rather peculiar appearance. The patient presents with acute symptoms of a loss of the inferior visual field, and this is why he or she has been referred to you as a retinal surgeon.

- During the examination, a retinal elevation with a characteristic shape is found, i.e., with a straight borderline going from the disk toward the macula and equator, but **not to the ora serrata.**

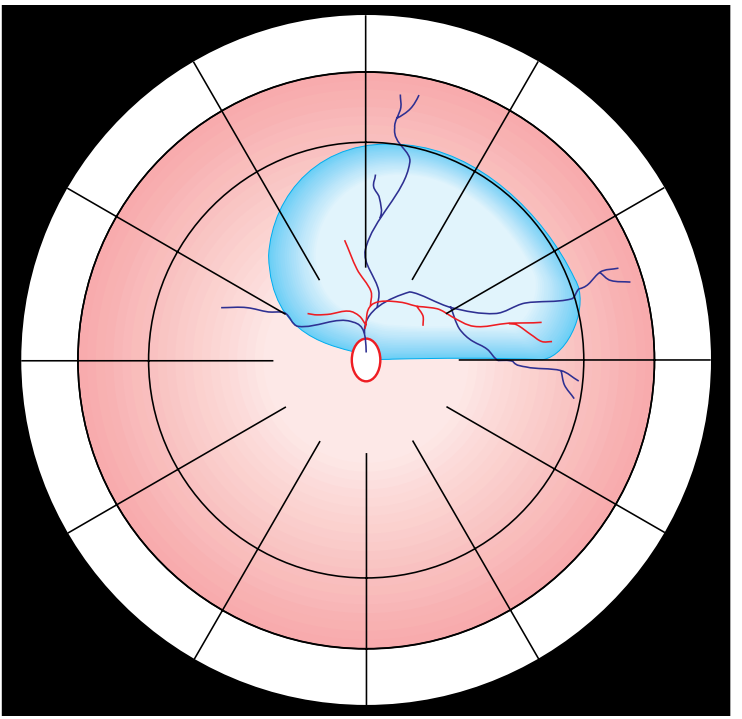

Fig. 5.**5** Ischemic retinal edema after closure of superior branch of a retinal artery. The posterior border of the elevation runs straight (!) to the macula and along the temporal raphe. Note that the anterior border of the edema does not extend to the ora serrata, but stops in the area of the equator (findings documented by H. Lincoff, M.D. in 1972)

? What is it? Could it be a superior detachment of rhegmatogenous origin?

▶ **No, and for the following reasons:**
- The height of this retinal elevation is inconsistent with its extent, which means it is too shallow to be a rhegmatogenous detachment
- Due to its extent it should spread to the ora, but it does not
- The inferior border of the elevation is straight and not convex, as it would be in a rhegmatogenous detachment.

The diagnosis is therefore one of a superior retinal artery occlusion, and the findings now being seen represent the resulting edema.

- At angiography, the primarily occluded vessel would be found to have reopened, and all that is left is the residual edema, which will remain for a couple of weeks and mimic a flat retinal detachment.

5.2.3 Optic Pit Maculopathy

Figure 5.**6** shows a special central retinal elevation that is 2-fold [4, 5]. It consists of a schisis-like elevation, and when one looks more

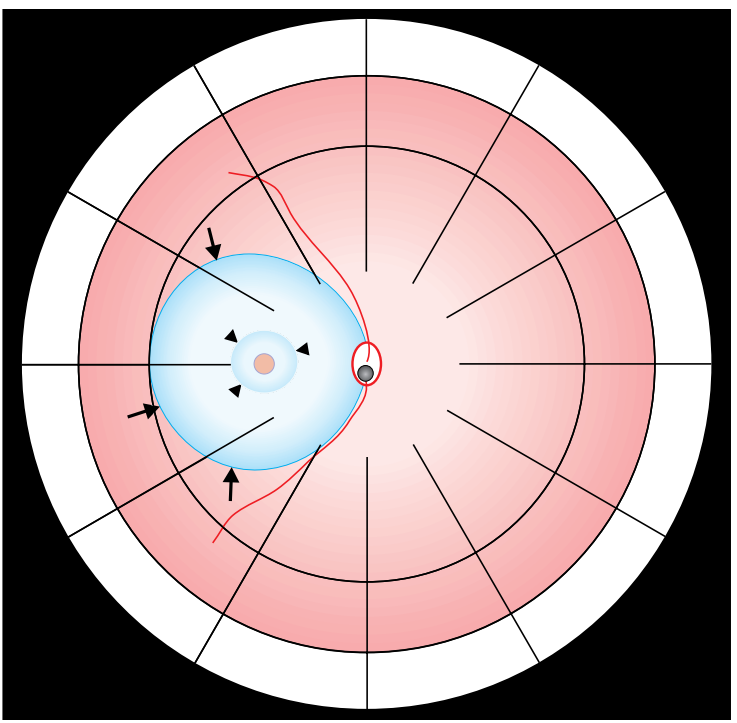

Fig. 5.**6** Optic pit with 2 macular elevations. There is a schisis-like separation extending beyond the posterior pole and to the disk (arrows) and a shallow smaller outer layer detachment in the center of the macula (arrowheads) with a **hole in the outer layer.**

carefully, another elevation is observed underneath the first one that is less extensive. If the fundus is examined with stereopsis, a sort of dome can be recognized in the center, with another one of a smaller extent underneath it.

? What is the diagnosis?

▶ It is an optic pit syndrome.

The internal layer separation, the schisis-like cyst, is hard to recognize because it is extremely transparent, and it may be easier to recognize the outer layer detachment of a lesser extent. The hole in the center is in the external layer. These findings were recently confirmed by OCT (optical coherence tomography) [6].

● This syndrome of an internal layer separation combined with an external layer detachment is so unique that an optic pit syndrome can be diagnosed even if the optic pit, which is sometimes hidden in deeper layers of the optic nerve, is not visible.

There are several treatment options. An intraocular gas bubble can be injected, and with special positioning of the patient's head, the schisis fluid can be massaged downward, i.e., out of the macular area, to improve the central visual field [6]; or the condition can be treated with vitrectomy, followed by gas injection with head positioning as well.

● **However, it should be borne in mind that the 2-layer central elevation never progresses toward the ora and there is no threat of a rhegmatogenous detachment.**

5.2.4 Tractional Retinal Detachment

These detachments are caused by vitreous traction, and are **characterized by concave borders and concave surfaces**.
They can be peripheral, reflecting traction at the area of the vitreous base or anterior to it, e.g., after a vitrectomy; or they can be central,

as is often seen in diabetic patients; or they can be at any location, due to traction caused by perforating injury, preceding surgery, or an inflammation.

- In most patients presenting with a tractional retinal detachment, the condition is of diabetic origin.

First of all, it should be noticed that the elevation in Figure 5.**7a** has concave borders and concave surfaces; there are no convexities.

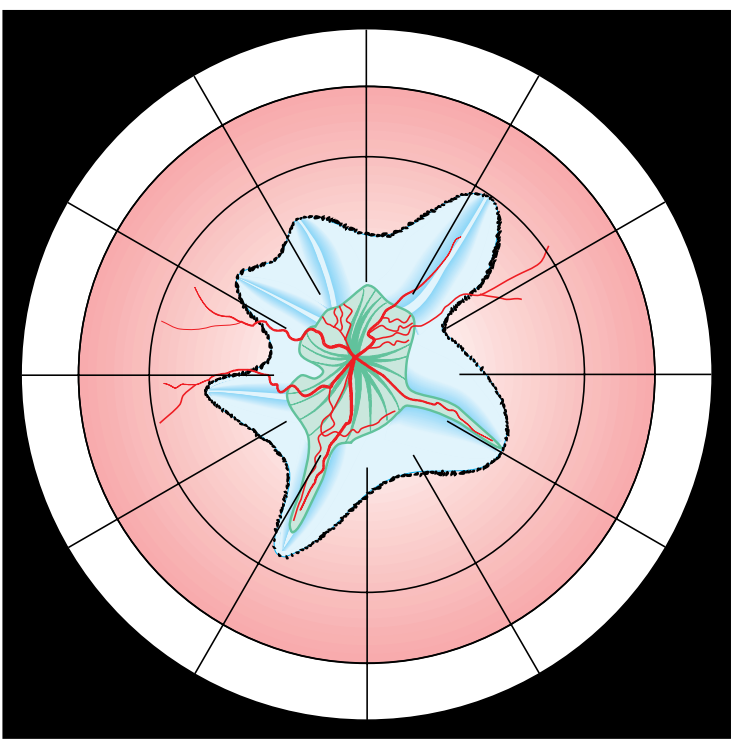

Fig. 5.**7 a** Tractional retinal detachment in a diabetic. The retina is adherent to a central proliferative membrane which is exerting traction on the retina and causing retinal elevation, with concave surface and concave contours. Due to the long duration of same extent, there are pigment demarcation lines at the borders.

This is of course an example of diabetic proliferative vitreoretinopathy, and there are no holes.

- Anything with a concave surface does not have a retinal hole (with 1 exception, discussed below).

This diabetic central traction is caused by adherence of the retina to the contracting posterior hyaloidal membrane. The retinal elevation is oriented symmetrically around the lines of adhesion, and it spreads slowly toward the periphery. This can be recognized by the successive pigment demarcation lines secondary to the increased contraction of the posterior hyaloidal membrane. This patient (Fig. 5.**7a**) still has the peripheral retina attached, and is able to walk about.

And then the patient may suddenly call you and say, **"Everything has gone within 1 hour".**

? **What has happened?**

When the patient comes to the office, the fundus presents as such (Fig. 5.**7b**). The retinal elevation is now convex, and the retinal detachment has progressed toward the ora serrata, because it has developed a full-thickness retinal hole.

- Therefore, when traction detachments develop a hole, they instantly become a rhegmatogenous detachment, progressing rapidly toward the ora, and become convex.

If this hole could be closed, the detachment would return to its former state of concavity, and the patient would recover the peripheral visual field. But if a vitrectomy with membranectomy is performed, it may even be possible to flatten the retina altogether.

Rhegmatogenous detachments originating from a tractional detachment can have different extensions, depending on the position of the hole and the lines of traction. When the hole is central, as

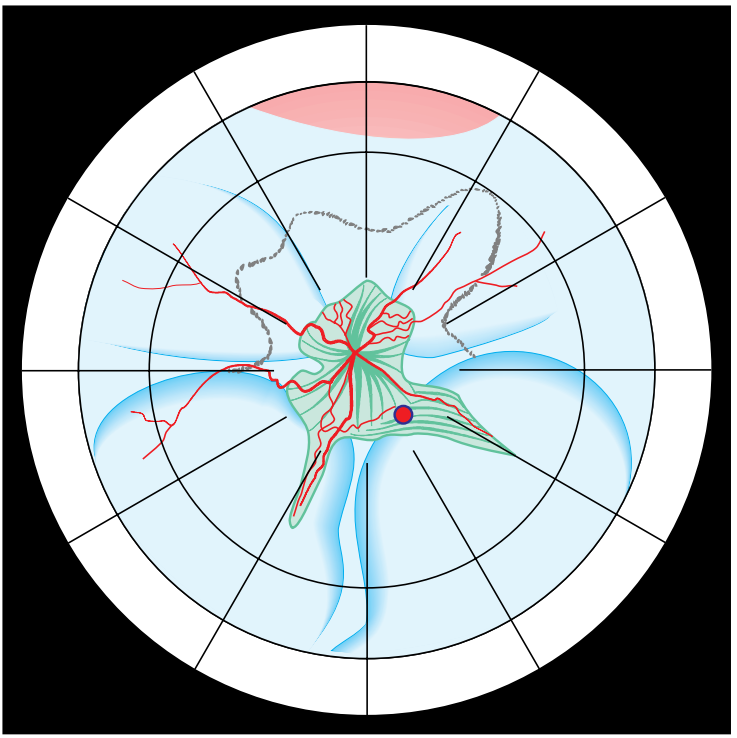

Fig. 5.**7 b** The tractional retinal detachment in Fig. 5.**7 a** has become a rhegmatogenous detachment due to a hole in the posterior retina at 5 o'clock. The detachment has become bullous (convex) inferiorly, and has spread to the ora in spite of a posterior break due to extensive traction.

in this patient (Fig. 5.**7b**), subretinal fluid quickly progresses to the bottom of the eye and rises about 2 clock hours above the hole, symmetrically on either side of the disk. If the superior traction is not extensive, a small wedge of retina may remain in place superiorly, but if the traction increases, it carries the fluid all the way to the top of the eye.

In the diabetic eye, it is essential to differentiate between rhegmatogenous and tractional retinal detachment.
The characteristics of tractional detachment are:
1. Concave surface and contours
2. Development of pigment demarcation lines
3. Absence of a hole
4. **However, the patient should be alerted to the fact that a sudden loss of visual field may occur, due to a full-thickness hole causing an additional rhegmatogenous detachment.**

5.2.5 Tractional Retinal Schisis

Figure 5.**8** shows a further finding in a diabetic eye.

The surface and the borders of this elevation are **concave, despite of retinal holes.**

What is wrong?

If these were full-thickness holes in a tractional retinal detachment, as discussed above, the surface and borders would have become convex, and the elevation would progress inferiorly and toward the ora. **However, this elevation has not acquired convexities in spite of the presence of holes, because it is a tractional retinal schisis.**

In this case, the pull on the retina by an adherent vitreous membrane has only detached the inner layers of the retina, giving the shape of a tractional detachment, but it is actually only a tractional schisis. This can happen in a diabetic eye due to a defective vascular system and retinal ischemia.

However, there are important diagnostic and prognostic differences between the 2 similar findings of tractional detachment and tractional schisis.

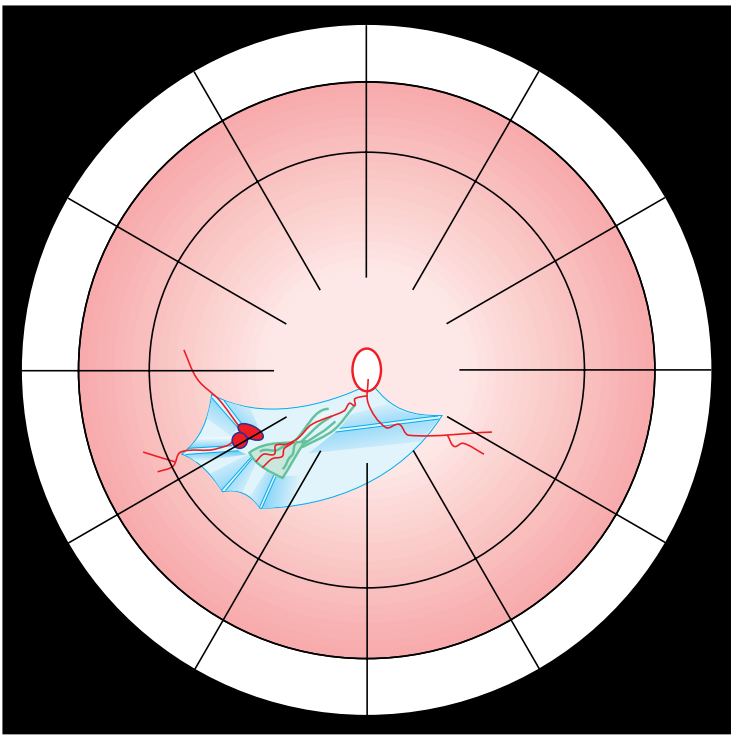

Fig. 5.8 Tractional retinal schisis in a diabetic with breaks along a vessel. In a course of 10 years (observation by H. Lincoff, M. D.), this neither progressed nor formed a pigment demarcation line. Instead, the internal layers subsequently disintegrated, and only slightly elevated borders of the former schisis were left barely visible.

- Tractional retinal schisis spreads slowly and symmetrically beneath the point of traction, it is limited in extent and does not develop pigment demarcation lines, because it is only a split of the inner retinal layers.
  Retinal tears may develop along the vessels, and the tractional schisis will still remain concave in its surface and borders.
  - These holes do not cause a sudden change in contours or in the patient's visual field.

In spite of the tears, the surface remains concave, and this alone provides additional reassurance that the condition is one of a retinal schisis. Generally, it is limited in extent, because the internal layers will disintegrate more and more; over time, the traction decreases, and as a result this type of elevation becomes less of a problem.

5.2.6 Clinical Study

There were 200 diabetic patients with retinal elevations examined; **in 4 of 10 patients (42%), tractional schisis was present, but not tractional detachment** [7].

If vitrectomy were to be performed in tractional schisis, therefore, the patient would not benefit much. Why? Because the treatment would not improve the visual field significantly.

> It should be borne in mind that in a diabetic eye, it is **essential to differentiate between tractional schisis and tractional detachment, because otherwise *4 of every 10 patients who only have tractional schisis* will be exposed to surgery that will not benefit them significantly, except for a slight improvement if the macula is involved.**

In a classic publication, Lincoff et al [7] listed important guidelines for this mandatory differential diagnosis prior to performing invasive surgery.

5.3 Dependent Retinal Elevations

5.3.1 Exudative Detachments

Exudative detachments of the retina occur in the presence of an intraocular tumor, pigment epitheliopathies or inflammatory disorders, such as Harada's disease, etc.

? What is unique about exudative detachments?

▶ They are dependent and symmetrical around 6 o'clock. If the patient is examined lying flat, the fluid spreads posteriorly and if the patient is turned onto one or the other side, the fluid will run up symmetrically on either side (Fig. 5.**9 a**).

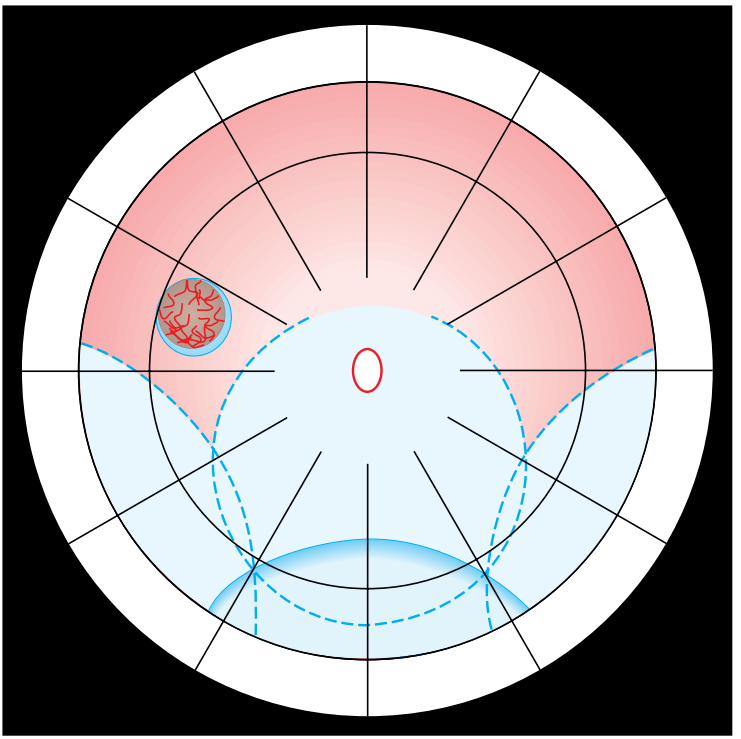

Fig. 5.**9 a** Early stage of an inferior exudative detachment due to a choroidal melanoma at 9:30. In the vertical position, the detachment extends between 5 o'clock and 7 o'clock. The broken lines indicate symmetrical shift of fluid due to change in position (with the patient lying supine on a stretcher and the head being tilted to either side).

- This type of patient will describe **not being able to see well in the morning,** because during the night the fluid has moved toward the macula, whereas during the day the fluid will descend, improving the vision.

In women, an exudative detachment is usually due to a choroidal melanoma or a metastatic carcinoma from the breast, and in men it is usually due to a choroidal melanoma or a metastastic carcinoma

from the lung. When this type of detachment is seen—i.e., bullous and symmetrical around 6 o'clock—a tumor should therefore be looked for initially. If there are cells in the vitreous, an inflammatory condition should be considered.

The exudative detachment can become more bullous, resulting in what are known as "kissing bullae," symmetrical around 6 o'clock, and if it becomes even more bullous, it can touch the lens (Fig. 5.**9b**). When this occurs, it means that the detachment has even dissected underneath the epithelium over the pars plana.

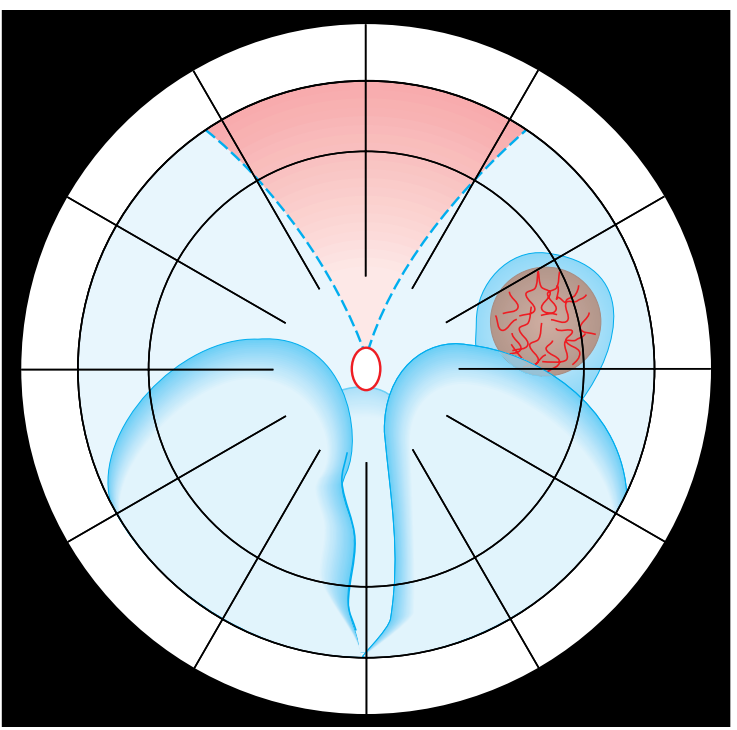

Fig. 5.**9b** Advanced stage of an exudative detachment due to a larger choroidal melanoma between 2 o'clock and 3 o'clock. There is a bullous inferior detachment with "kissing bullae" being symmetrically around 6 o'clock. The broken lines define the symmetrical shift of fluid into the upper quadrants when the patient is lying flat on a stretcher and the head is turned from side to side.

Differential diagnosis of an exudative detachment:

1. If the patient lies flat and the head is turned to one side or the other, with an exudative detachment the fluid will move into the upper quadrants, and the
   change will be symmetrical
2. But if there is a detachment with a hole at 6 o'clock, and the retinal elevation will not be bullous, but flat, then there will be
   no change in contours
   due to positioning of the patient's head to either side.
3. If the patient's head is tilted to one or the other side and the
   change of contours is asymmetrical,
   then it is not an exudative detachment, but rather a superior detachment, and a search must be made for a hidden break in the superior quadrant (see Rule 4: Location of the primary break, page 15).

Once the diagnosis of an **exudative detachment** has been ascertained, extensive screening must be started. **The patient should be asked to sleep in an elevated position in the meantime, so that the macula does not detach overnight.**
Treatment appropriate to the etiology should then be started.

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6 The Fellow Eye

6.1 Diagnostic Procedures

Before any surgery is carried out on the eye with a detachment, the fellow eye should be examined—because a break or lattice degenerations may be localized symmetrically.

- **It is therefore a rule to study the fellow eye:**
  - To obtain a better understanding of the eye undergoing surgery
  - To detect a symmetrical break if present

If in the fellow eye a horseshoe tear or a round hole is found in attached retina, it can be treated using laser. If a hole is found with a localized detachment, double patching and lying the patient flat might be tried (this is done prior to surgery anyway), as this may flatten the retina so that laser or cryopexy applications will be sufficient to secure the retina.

- If lattice degeneration with "holes" is found, it should be remembered **that in general, round holes within lattice are only lamellar holes, and do not cause detachment.**

However, one has to be critical. The borders of lattice degeneration should be analyzed using dynamic scleral depression, as this may reveal an **undetected tear on the edges of the lattice degeneration.**

- Symmetrical lattice degenerations in the fellow eye of **more than 1 clock hour** in comparison to the detachment with only 1 break in the other eye, are a reason to be hesitant about "active" prophylaxis.

? "Active" prophylaxis, what does this mean?

▶ Treatment with cryopexy or laser coagulation.

Therefore if the prophylactic treatment were to be more extensive than the break it is intended to prevent, it might be excessive.

? Instead, "passive" prophylaxis is advisable. What does this mean?

▶ Explain to the patient the symptoms of a retinal detachment (usually accompanying a posterior vitreous detachment), and how to test for the visual field.

Advise the patient to do this on a regular basis. If a detachment is developing, this regular testing will allow early diagnosis before the macula detaches.

6.2 Epidemiology

According to epidemiological studies, the prevalence of lattice degeneration in the general population is between 5% and 10%. The life-long risk of a retinal detachment in such eyes is about 1% [1]. However, lattice degeneration in the fellow eye of a patient with a detachment increases the risk of a break or a detachment, and more so if the vitreous in the fellow eye has not yet detached. Before the patient is sent home after surgery, therefore, in addition the fellow eye should be examined for the presence of a posterior vitreous detachment, and this is best done using ultrasonography. If a posterior vitreous detachment has not yet occurred, then in the presence of lattice degeneration, the chances of the fellow eye developing tears or a retinal detachment are between 10% and 25%. For such a patient, this means that there may be a 1 in 4 chance of developing a detachment in the fellow eye.

● When detachment patients return for their follow-up examinations, the fellow eye should therefore be examined first.
This is because, in perspective, the risk for the patient of developing another detachment is greater in the fellow eye than in the treated eye, especially if the posterior vitreous has not yet detached in this eye.

? Which retinal findings should now be treated in the fellow eye, i. e, "active" prophylaxis should be applied?

- **Definitely:**
  - Horseshoe tears
  - Round holes with acute symptoms, or when there is a positive family history
- **Possibly:**
  - Round holes in the superior temporal quadrant, even when they are asymptomatic
  - Lattice degeneration of up to 1 clock hour that is symmetrically located to a horseshoe tear in the eye with detachment
- **Not to be treated:**
  - Any lattice degenerations, even with pseudoholes, without presence of a detachment in the fellow eye
  - Extensive lattice degenerations in presence of a detachment in the fellow eye
  - Inferior asymptomatic round holes

6.3 Prophylactic Treatment

If the decision has been taken to treat an attached tear, the treatment should be carried out adequately to provide real prophylaxis against detachment. The entire retinal tear has to be surrounded with interrupted lesions. This can be done either with a double row of interrupted laser lesions (200–500 µm in diameter, Fig. 6.**1**), or with 1 row of interrupted cryopexy lesions (Fig. 6.**2**). Special care should be taken to seal the anterior edge of the tear, particularly anterior to the operculum of a horseshoe tear, where vitreous traction might still be present.

● However, no attempt should be made to coagulate, especially with high intensity, around a break with detached or partially detached edges. Unless it is very limited (1/2 dd), treatment beyond the edges of a detached tear will eventually fail, particularly if the detachment is in the superior retina.

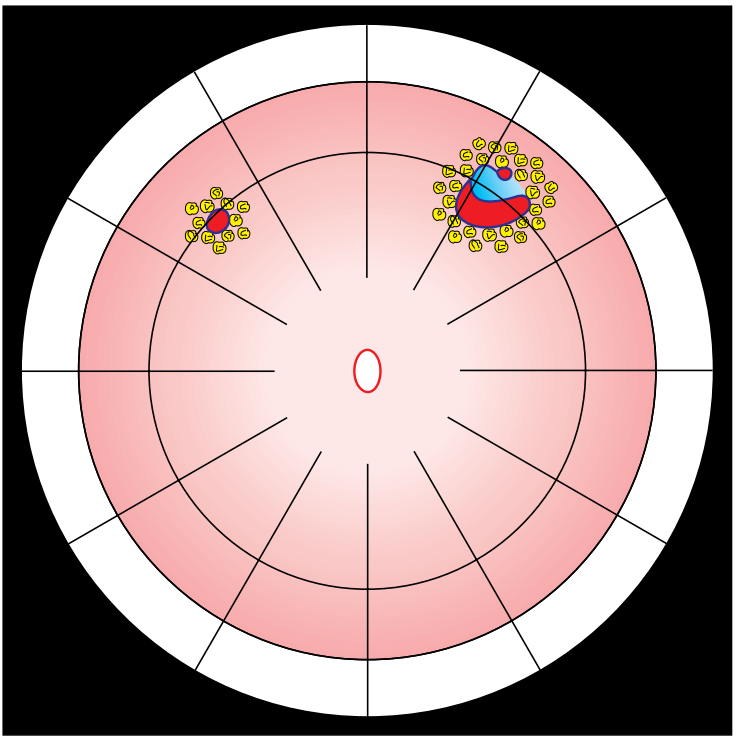

Fig. 6.1 Prophylactic treatment of an attached round hole and horseshoe tear with laser. There is a double row of interrupted laser lesions of 200 µm in diameter. The operculum of the horseshoe tear in particular has to be sealed off toward the ora in order to counteract future traction.

If overnight double patching does not reattach the break substantially (especially a superior break), it should be buckled, preferably using a temporary balloon. A gas injection does not represent an alternative treatment, of comparable low morbility; this is due to the complications associated with gas, such as proliferative vitreoretinopathy or the development of secondary breaks (see Part 2: Chapter 10. Temporary Gas Tamponades without Drainage: Minimal Intraocular Surgery for Retinal Detachments).

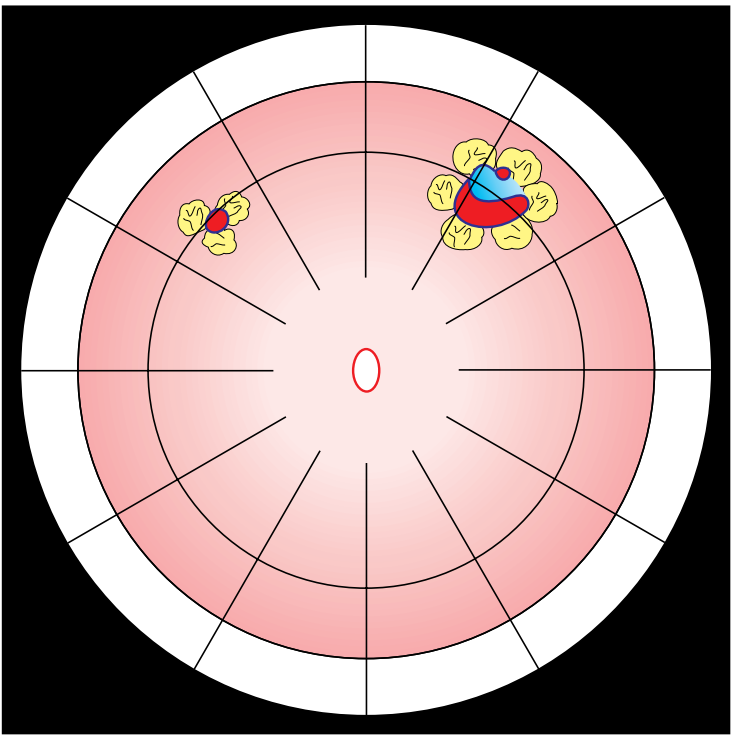

Fig. 6.**2** Prophylactic treatment of an attached round hole and horseshoe tear using cryopexy. The round hole at 10:30 is surrounded by 1 row of interrupted cryopexy lesions, as is the horseshoe tear at 1 o'clock. Special care is taken to seal off the operculum toward the ora, where future traction might be exerted.

Reference

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7 Cryosurgery

7.1 Cryosurgery in Relation to Retinal Detachment Surgery

Retinal detachment surgery began to progress significantly after 1930, thanks to Gonin [1]. His original concept—that the cause of a detachment is a retinal hole and that reattachment can be achieved using diathermy-induced inflammation around the break and drainage of subretinal fluid—improved the prognosis to such an extent that for a considerable time no one saw any need for further change. When, in 1933–34, Deutschmann [2] and Bietti [3] reported treatment of retinal detachment by freezing the break with solid carbon dioxide, there was little response. The instruments for applying diathermy were satisfactory, and the retinal adhesion achieved was effective. Cryosurgery of the retina remained an idea whose time had not yet come.

But things do change: 20 years later, in 1953, an extraocular detachment technique appeared, with the introduction by Custodis of a revolutionary technique for retinal detachment surgery [4].

The Custodis technique eliminated 3 major hazards:

1. Perforation for drainage of subretinal fluid
2. Intravitreal injection to restore volume
3. Scleral dissection to save part of the scleral wall from diathermy necrosis.

This segmental buckle technique without drainage was made possible by the use of an elastic explant (Polyviol), compressed precisely over the retinal hole, which had, however, been treated with full-thickness transscleral diathermy. The technique was very nearly abandoned—not because the procedure did not work, but because of a high rate of extraocular infection (in 6 of the 25 eyes treated) and endophthalmitis (in 4 of the 6 infected eyes) reported by Schepens et al in 1960 [5].

Lincoff et al [6], who adopted the Custodis operation, experienced similar complications, but much less frequently, and were convinced of the correctness of the procedure. Lincoff therefore searched for ways of eliminating what he concluded were

The most likely roots of the problem with the Custodis technique:
1. The necrotizing effects of diathermy
2. The toxic effects of Polyviol.

In 1963, Lincoff and his group [7] began creating experimental lesions in animal eyes using carbon dioxide applicators borrowed from dermatology. In the same year, the Cooper–Linde Neurosurgical Unit, which used liquid nitrogen to cool a brain probe, was developed. Lincoff and McLean modified the device to make it suitable for the eye, and designed a smaller and more maneuverable instrument. This provided controlled temperatures at the end of an insulated probe, ranging from +37 °C to –180 °C. This first liquid nitrogen instrument was complicated, but was excellent for research purposes and provided extensive data. In subsequent years, the Linde instrument was replaced by more dependable devices using carbon dioxide or nitrous oxide gas—cryogenic agents that are easier to handle than liquid nitrogen. Lincoff had thus identified in cryosurgery the method he was looking for in order to retain the Custodis concept.

In addition to replacing diathermy by cryosurgery, Lincoff exchanged the somewhat irritative Polyviol explant with an inert elastic plombe made of silicone sponge [8].

However, this new extraocular cryosurgical detachment operation initially still had to overcome many problems before being accepted.

? What was it about this approach that was so different and difficult to accept?

- There were doubts about whether a cryosurgically induced **adhesion would be strong enough.** Directly after the cryosurgical application, there were no marks on the sclera, and almost no changes in the retina were visible ophthalmoscopically.
- There were even greater doubts about whether **subretinal fluid would be absorbed postoperatively** after a nondrainage procedure, particularly if the break was still elevated above the buckle during the operation.

7.2 Research and Development in Cryosurgery

These doubts concerning cryosurgery can be overcome by recalling a few facts. The primary advantage of cryosurgery was, and still is, that it can penetrate the sclera and create a firm retinal adhesion without damaging the scleral wall. This made feasible an important change in detachment surgery that had been waiting in the wings: Full-thickness scleral buckling (without lamellar dissection needed to preserve the scleral wall when diathermy is applied) and suturing an elastic explant onto the cryopexy-treated sclera, eliminating the need for drainage.

- With the development of cryosurgery, the Custodis technique could develop and reach its deserved potential

With the advent of cryosurgery, many surgeons switched from the Schepens technique, in which solid silicone structures were buried in lamellar scleral dissections, to using a full-thickness scleral operation [9].

It is difficult nowadays to understand why, at its inception in the 1960s, cryosurgery (now termed cryopexy) was generally reserved for simple detachment problems in which there was little traction; diathermy remained the standard method of choice. The reluctance to use cryosurgery was due to uncertainty about whether the cryopexy-induced adhesion was strong enough. These doubts persisted during further animal experiments by Bellows [10], Boeke and Hollwich [11], Oosterhuis et al [12], and Toernquist [13].

- To rescue this new thermal modality for the newly developed local buckling technique without drainage, the cryosurgical adhesion had to be studied more extensively in additional animal experiments.

This was done at the end of the 1960s by Lincoff and Kreissig [14, 15] and Kreissig and Lincoff [16, 17], and the author addressed the problem in her postdoctoral thesis, *The Ultrastructure of the Cryopexy Adhesion in Retinal Surgery* [18] in 1972. In collaboration with Bloch, a

biomathematician, extensive animal experiments were undertaken.

Answers were sought to the following questions:

1. How does the strength of the cryopexy-induced adhesion compare to that produced by diathermy?
2. Are there differences in the strength of adhesions produced by light, medium, and heavy applications of cryopexy or diathermy?
3. How many days after treatment is the maximum adhesion obtained?

The results of this extensive research project provided conclusive evidence capable of reassuring clinicians that cryopexy was a suitable alternative to the time-tested modality of diathermy.

The research done on cryosurgery represented the premise that **minimal extraocular surgery for retinal detachment** had finally become the primary treatment—and during the last 25 years, it has become and remained the method of choice.

7.2.1 Dosage of Thermal Applications

The experiments were carried out in animal eyes under ophthalmoscopic control. Use of a more objective quantification, such as temperature and time, was considered but rejected, because it did not imitate the clinical situation under investigation. After all, the purpose was to compare the clinical entities of light, medium, and heavy applications. All thermal lesions were applied transconjunctivally in 336 eyes (168 rabbits) [18–20].

- **Dosage of cryosurgery**
  - **Light cryosurgical application:** Freezing caused the **choroid to blanch**. After removal of the cryoprobe, the lesion was hardly perceptible.
  - **Medium cryosurgical application:** Freezing was sustained until the **retina first turned white**. With removal of the cryoprobe, the white in the retina faded, leaving a faint gray area representing intraretinal edema.
  - **Heavy cryosurgical application:** Freezing was sustained for **3 seconds after the retina first turned white**. When the probe was removed, an opaque lesion persisted.
- **Dosage of diathermy**
  - A light application of diathermy caused the faintest gray response in the retina.
  - The medium application was stopped when the retina turned white.
  - In the heavy lesion, the application was continued for 3 seconds after the retina turned white.

7.2.2 Adhesive Strength of Thermal Lesions

As it was known from earlier experiments [15] that the normal retina will tear when subjected to a force of 300 mg, the thermal lesions were placed at the ends of the myelinated fibers to allow pulling with the myelinated bundle on the retinal adhesion. The myelinated bundle itself was able to withstand a force of 1 850 mg. All 640 thermal lesions (2 in each rabbit eye) were tested at various time intervals with a pulling experiment, as demonstrated in Figure 7.**1.** There were 328 diathermy and 312 cryopexy lesions.

▶ **Cryosurgical lesions**

The lesions after cryosurgery increased in strength with the intensity of the application. There were 3 distinct levels of adhesive strength, corresponding to the light, medium, and heavy applications.

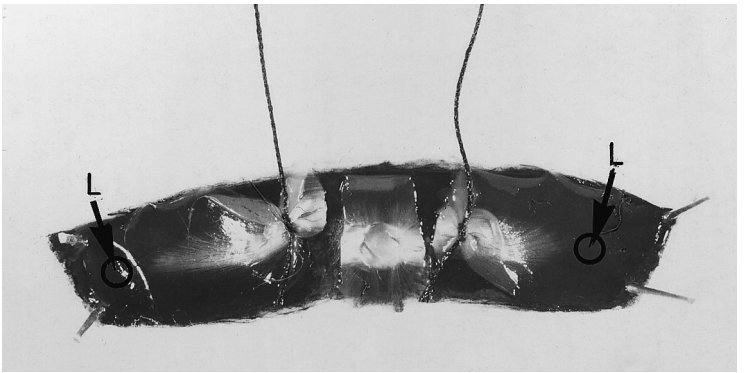


Fig. 7.**1** *Flat preparation of a rabbit retina.* Lesions (L, pointing to the encircled lesion) have been placed at the peripheral ends of myelinated fibers. The proximal ends have been severed at the disc and grasped with a silk suture in preparation for pulling [from ref. 21].

- **Adhesive strength of crysurgical lesions:**
  - A light lesion resisted an average pull of 300 mg
  - A medium lesion 575 mg
  - A heavy lesion 1 175 mg (Fig. 7.**2**)

▶ Diathermy lesions

No such stratification was observed with diathermy. The adhesive strength shows a range of 50–1 550 mg, but there is poor correlation with the intensity of application. A light diathermy application was sometimes able to yield a strong adhesion. The average adhesive strength of the diathermy lesions, regardless of whether the application was light, medium, or heavy, was capable of resisting a pull of approximately 500 mg—a range approaching that of a medium cryosurgical lesion (Fig. 7.**2**).

7.2.3 Development of Adhesive Strength over Time

Cryosurgical adhesions increased rapidly in strength after the 2nd day; diathermy lesions increased in strength after the 4th day.

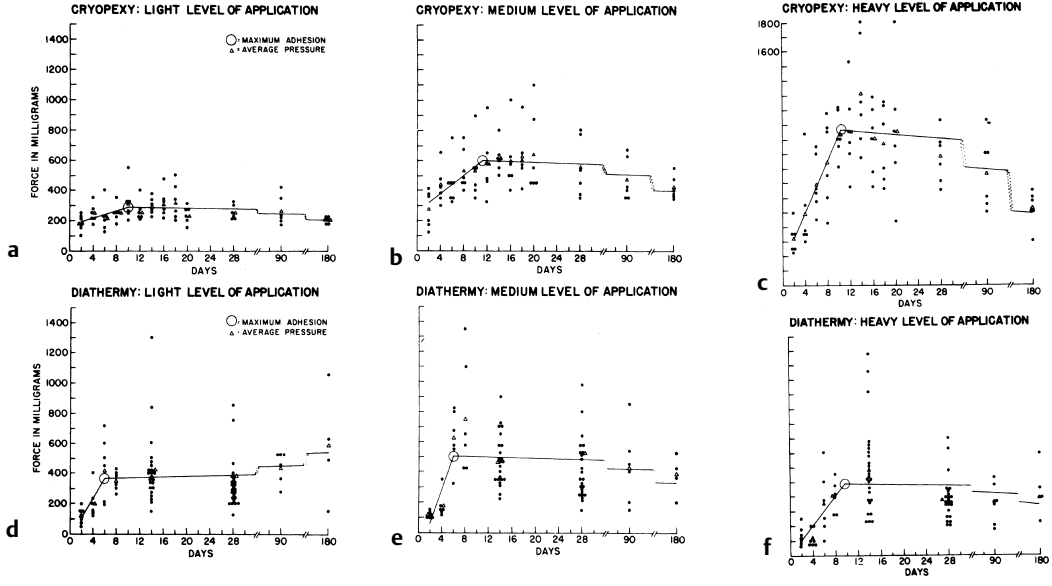


Fig. 7.**2** *Graphs of the relative adhesiveness of cryopexy and diathermy.* Solid dots represent lesions, and circled points represent joined points (days of maximum adhesion) of the 2 straight lines fitted to the data. The value for the average adhesiveness in each group is represented by a triangle. The abscissa represents the time in days between application and detachment, and the ordinate represents milligrams of force required to separate the lesion [from ref. 21.]

a–c Cryopexy: light (**a**), medium (**b**), and heavy (**c)** applications.

d–f Diathermy: light (**d**), medium (**e**), and heavy (**f)** applications.

Diathermy lesions reached their maximum adhesive strength by the 10th day;

- The adhesive strength after cryosurgery reached its maximum by the 12th day.

7.2.4 Ophthalmoscopic Appearance of Cryosurgical Lesions

The early ophthalmoscopic appearance of a cryosurgical lesion depends on the transparency of the retina.

▶ **Light cryosurgical lesion**

On the 1st postoperative day, it is apparent that pigment epithelium is damaged, since the lesion appears as a pale patch of pigment epithelial edema. On the 2nd day, a thin white outer ring and a thin black inner ring become apparent at the edge of the lesion. The outer white ring defines the edge of the untreated area. At the center of the lesion, the pigment epithelium appears less dense, and shows some pigment aggregations. During the 3rd and 4th day, the lesion develops a fine stippled appearance.

On the 5th day, coarse pigment clumping is evident. The peripheral rings of the lesion are no longer apparent. On the following days, there are small changes in the distribution of pigment epithelial clumps, and less dense choroidal pigment in the background.

▶ **Medium cryosurgical lesion**

On the 1st postoperative day, the lesion appears grayish-white, with a velvet-like character. The retina is semiopaque, and limits the view of the changes occurring at the levels of the pigment epithelium and the choroid. On the 2nd day, the lesion looks uniformly grayish-white. In the periphery, a thin white line appears, defining the untreated retina. The retinal edema decreases over 5 days.

By the 6th day, marked pigment clumps on a yellowish-white background become evident. The entire lesion appears paler than the untreated retina. In the center of the lesion, large choroidal vessels become visible.

▶ **Heavy cryosurgical lesion**

The opaque retinal edema is greater, and persists for a week. The retinal edema regresses slowly, beginning at the periphery of the le-

sion and progressing slowly toward the center. First, a thin white line appears at the periphery, followed by pigment clumping at the center.

On the 14th day, the lesion is characterized by large pigment clumps on a very pale, white to yellow background.

● Eventually, the retina in a **heavy lesion** appears reduced to a thin shiny membrane. There are often cystic changes, or even holes, in the inner layer of this reduced and fragile retinal layer.
This type of lesion should be not applied in clinical practice!

7.2.5 Histology of Cryopexy Lesions

The investigation of the strength of the cryosurgically induced retinal adhesions thus demonstrated a stratification of adhesive strength into 3 levels that varied directly with the intensity of the cryosurgical applications, and were as strong or sometimes stronger than after diathermy (Fig. 7.**2**).

? **The question is now: What causes these different types of adhesive strength after the application of cryosurgery?**
Are they due to various numbers of adhesion bonds of a single type, or due to different types of adhesion?

▶ The 3 types of cryosurgical lesion—light, medium, and heavy—were studied using electron microscopy.

Here we can take an excursion into the fascinating world of the retina, its ultrastructure, and the process of scarring—which can in fact be observed in every practice by ophthalmoscopy. As already suggested by the pulling experiments on the adhesive strength, there are at least 3 different types of anatomical adhesion, details of which are given below.

To determine the anatomical pattern corresponding to the 3 levels of adhesive strength induced by cryosurgery, another ani-

mal experiment was carried out [18]. For this purpose, 136 light, medium, and heavy cryosurgical lesions were made in 68 rabbit eyes. The lesions were made under ophthalmoscopic control with the Linde instrument, set at –30 °C. The same criteria for the 3 different intensities of application were used as in the previous animal experiments. The cryosurgical applications were placed at the end of the nerve fibers, resulting in 2 lesions for each animal eye. The animals were sacrificed at various intervals, ranging from 4 days to 3 years. The different types of lesion—light, medium, and heavy—were studied using electron microscopy.

At least 3 different anatomical patterns could be discerned [16, 18], which were characterized as:
1. Interdigital
2. Desmosomal
3. Infiltrative

Retinal neuroepithelium has a remarkable ability to recover after cryosurgical injury (Fig. 7.**3**). The pattern of the healed lesion depends on the depth of thermal necrosis initiated by the cryosurgical application and whether the basement membranes are interrupted.

If the retina is necrosed by freezing to the level of the outer limiting membrane (Fig. 7.**4**), but the outer nuclei survive, the **rods regenerate and again interdigitate** with the villi of regenerated pigment epithelium (Figs. 7.**5,** 7.**6**). This new union, if pulled on, is stronger than the natural intraretinal adhesion.

If the thermal injury of cryosurgery penetrates to the nerve fiber layer, the outer nuclei and the rods do not regenerate. Adhesion develops between regenerating pigment epithelium without villous processes and processes of Mueller's cells. The adhesion is **desmosomal**—the densities representing desmosomes are easily recognized—between the smooth membranes of the neuroepithelial cells of the sensory retina and pigment epithelium (Fig. 7.**7**).

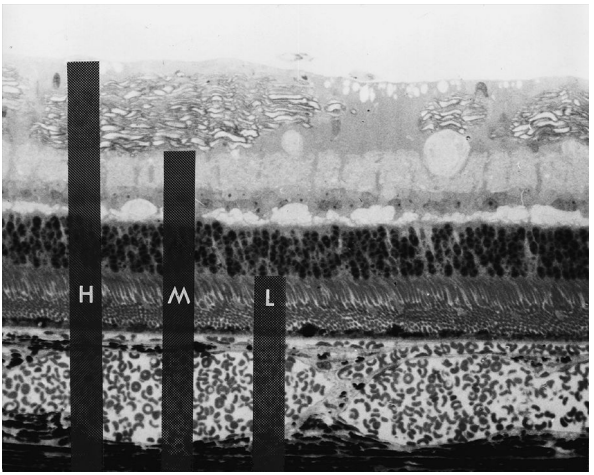


Fig. 7.3 *A section of normal retina demonstrating the penetration of cryogenic necrosis* (represented by columns) to the outer limiting membrane after a light application (L); to the nerve fiber layer after a medium application (M); and to the internal limiting membrane after a heavy application (H).

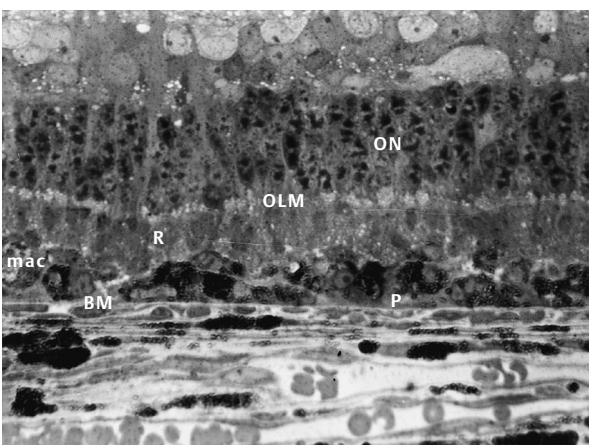


Fig. 7.4 *The retina 4 days after light cryopexy.* The section shows retinal necrosis to the level of the outer limiting membrane (OLM); the outer nuclei (ON), above, look normal. The basement membrane (BM) of the pigment epithelium (P) survives. There are large numbers of macrophages (mac) above. The photoreceptor elements (R) are necrotic [from ref. 18].

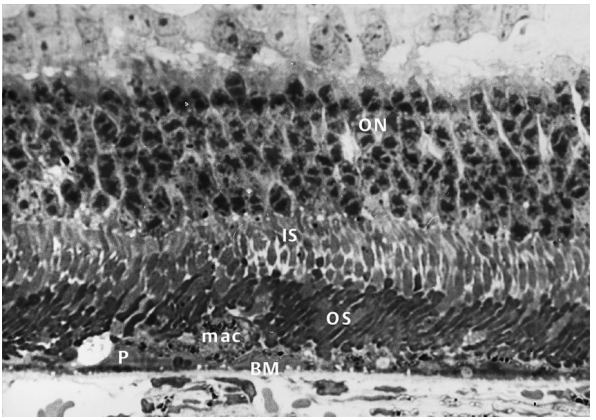


Fig. 7.**5** *The retina 14 days after light cryopexy.* The section shows recovery of the photoreceptor elements. The inner segments (IS) and outer segments (OS) are again in parallel columns, interdigitating with the pigment epithelium (P). A large macrophage (mac) among the outer segments is the most striking evidence of previous injury. The basement membrane (BM) of the pigment epithelium is intact. ON = outer nuclei [from ref. 18].

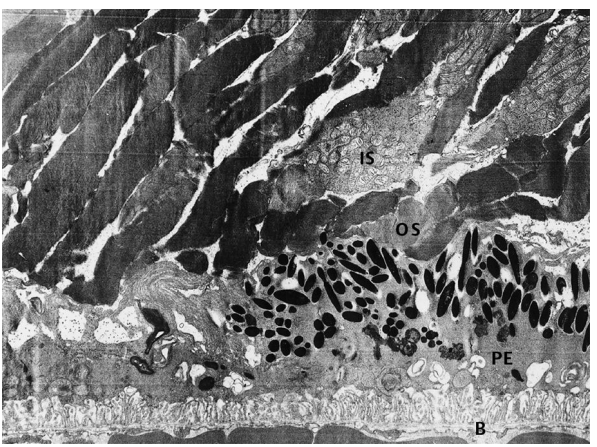


Fig. 7.**6** *The retina 14 days after light cryopexy.* The electron micrograph of the outer segments (OS) shows rods *interdigitating* with villi of pigment epithelium (PE). The outer segment discs are again in horizontal order. IS = inner segment [from ref. 14].

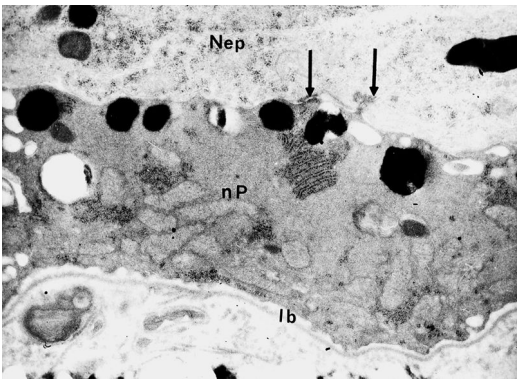


Fig. 7.**7** *The retina 28 days after medium cryopexy.* The electron micrograph shows *desmosomal* connection (arrows) between smooth membranes of adjacent neuroepithelial cells, i.e., the less specialized neuroepithelium (Nep) without finger processes and the new pigment epithelium (nP) without villous processes; lb = lamina basalis of pigment epithelium [from ref. 16].

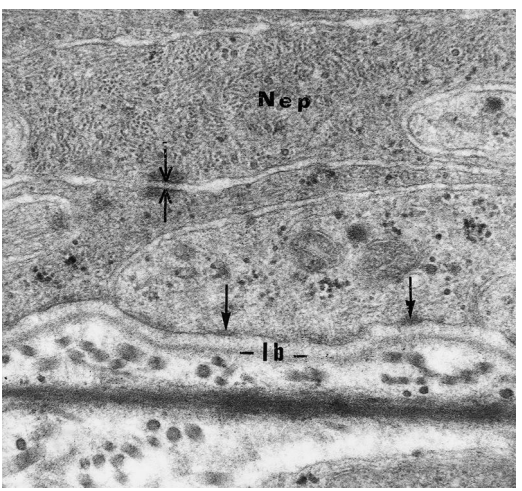


Fig. 7.**8** *The retina 28 days after medium cryopexy.* The electron micrograph shows undifferentiated neuroepithelial cells (Nep) of retina, which are connected to each other by desmosomes (double arrow), spread along the basement membrane (lb), and are attached to it with *hemidesmosome-like* structures (single arrows).

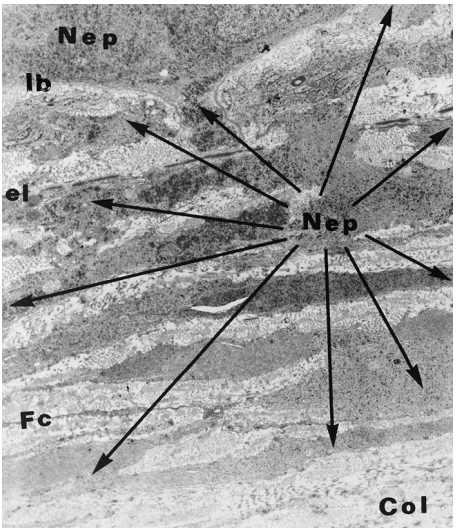


Fig. 7.**9** *The retina and Bruch's membrane 2 years after heavy cryopexy.* The electron micrograph shows *a chorioretinal scar by infiltration*. The thermal injury necrosed the basement membrane of the pigment epithelium (lb = lamina basalis). As a result regenerating *retinal neuroepithelium* (Nep) infiltrated the collagen lamellae (Col) of Bruch's membrane, crossed the level of elastic lamina (el), and penetrated into the adjacent choroid. Fc = fibrocyte.

? What does this tight desmosomal adhesion remind you of? Where else in the eye would you find such a strong adhesion?

▶ Analogous epithelial relationships are found over the ciliary body.

If the recovery of pigment epithelium is delayed, undifferentiated neuroepithelial cells of the retina may even spread directly along the basement membrane and attach to it, with structures resembling **hemidesmosomes** (Fig. 7.**8**). The residual retina is then a thin band of neuroepithelium between the inner limiting membrane and the basement membrane of pigment epithelium.

Finally, if the thermal injury by cryosurgery is severe enough to necrose the basement membrane of pigment epithelium, surviving neuroepithelium may **infiltrate** the collagen lamellae of Bruch's membrane [20] and cause a **chorioretinal scar** (Figs. 7.**9,** 7.**10**).

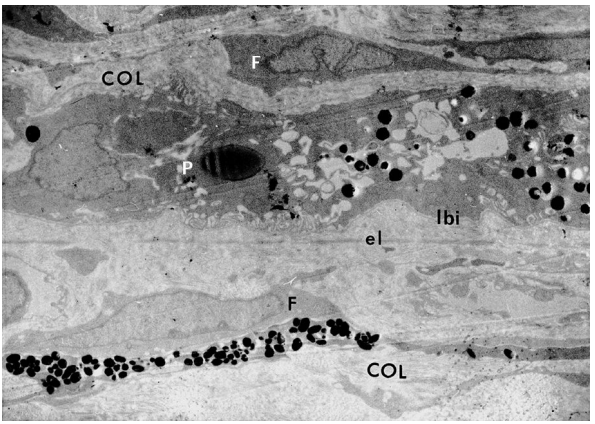


Fig. 7.**10** *The retina 28 days after heavy cryopexy.* The electron micrograph also shows a *chorioretinal* scar. Here, however, *collagen fibers* (COL) and fibroblasts (F) penetrate through a defect in the basement membrane (lbi = lamina basalis interna) of the pigment epithelium (P) into the overlying retinal tissue; el = elastic lamina of Bruch's membrane.

However, there is some evidence that an excessively heavy application of cryosurgery, penetrating the inner limiting membrane, may induce vitreoretinal adhesions. This would be an undesirable development in the course of detachment surgery.

— **Overfreezing should therefore be avoided, and a heavy application of cryosurgery should not be selected!**

7.2.6 Summary

There are at least 3 distinct types of anatomical mechanism that **produce retinal adhesions after cryosurgery**:

- **Interdigitation** of newly formed rods with villi of pigment epithelium, producing a mild adhesion.
- **Desmosomal** connection between the Mueller's cells and the smooth surface of a new pigment epithelium or the basement membrane of pigment epithelium, resulting in a strong adhesion.

- **Infiltrative or chorioretinal adhesion,** in which processes of Mueller's cells infiltrate the collagen lamellae of Bruch's membrane, yielding a very strong adhesion with a thin and fragile retina [21].

These different ultrastructures of the cryosurgical adhesion result in different adhesive strengths.

? Which aspects are most important to the clinician?

The following answers were obtained to the above questions posed concerning cryosurgery:

1. There is a **difference in the strength of the adhesions produced by light, medium, and heavy applications of cryosurgery,** but not of diathermy.
2. The **strength of the cryosurgical adhesion is predictable,** and can be controlled by ophthalmoscopic observation during application; this is not true of diathermy.
3. The **adhesive strength of the cryosurgical adhesion continues to increase for 12 days, up to:**
   - **300 mg for the light cryopexy application**
   - **575 mg for the medium application**
   - **1 175 mg for the heavy application**

7.3 Remodeling of the Cryosurgical Adhesion over Time

- The further question arises of whether changes in the structure of the cryosurgical adhesion take place over time, and if so, whether this has clinical implications.
  - The ultrastructure of adhesions therefore needs to be studied over time.

It should be recalled here that the maximum adhesion obtained by the medium cryopexy application at 12 days is mediated by depolarized cells [22]. However, repolarization of the pigment epithelium begins as early as 1 month.

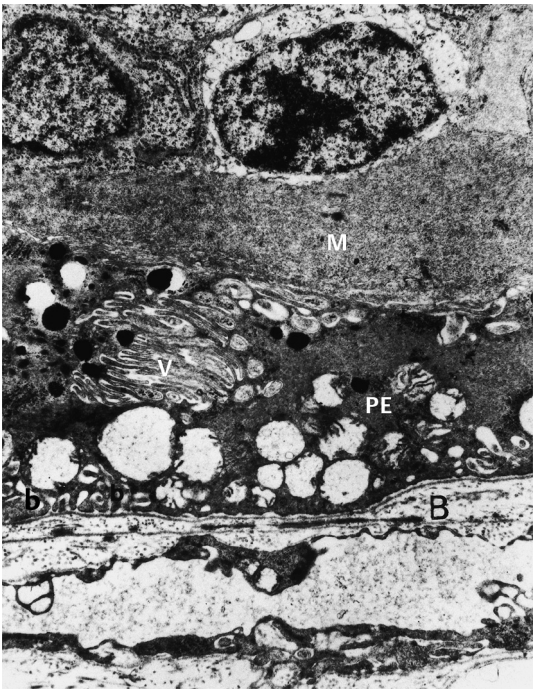


Fig. 7.**11** *At 3 weeks,* the pigment epithelial cells (PE) show signs of repolarization and differentiation—lateral villous processes (V), basal infoldings (b), and pigment granules. Note that the apical surface abuts the neighboring Mueller's cell (M), and still remains blunt and straight. B = Bruch's membrane.

▶ 1 month

Basal infoldings of pigment epithelium and apical processes become evident. Initially, the villous processes are disoriented and located between adjacent pigment epithelial cells. The apical surfaces continue to exhibit stretches of blunt cell membranes adjacent to Mueller's cells (Fig. 7.**11**). At this point, intercellular organization of the pigment epithelium also becomes apparent. Pigment granules reappear. The actin-like filaments, typical of the earlier migrating pigment epithelial cells, are no longer conspicuous.

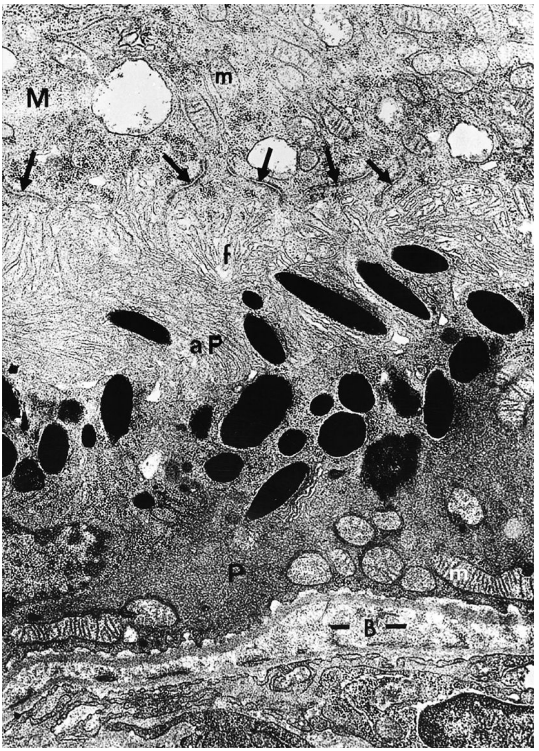


Fig. 7.**12** *At 20 months,* remodeling of the interface between pigment epithelial cells (P) and Mueller's cells (M) has resulted in exclusively intervillous adhesion, which is occurring between the long villous processes (aP) of the pigment epithelium and the shorter villi of Mueller's cells, which are finger-like (f). An outer limiting membrane (arrows) is differentiated by the Mueller's cells with characteristic junctions. Close to the basement membrane of the pigment epithelium are numerous mitochondria (m). B = Bruch's membrane. [from ref. 17]

▶ From 2 months to 3 years

The cells continue prolonged remodeling of their relationship. The blunt cell apposition of adjacent pigment epithelium and processes of Mueller's cells are progressively transformed into an interdigitating villous architecture (Fig. 7.**12**). The retinal pigment epithelial

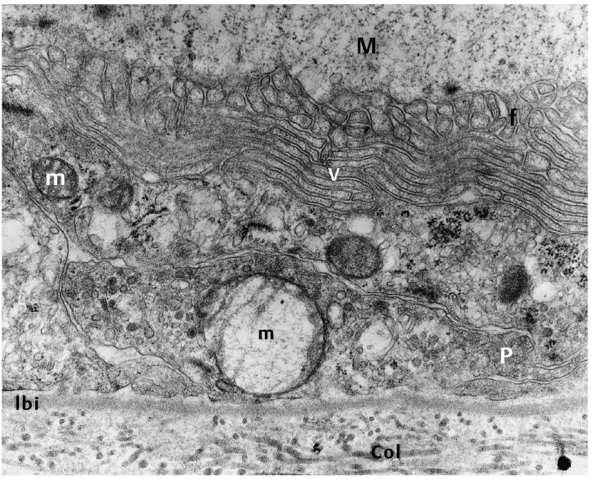


Fig. 7.**13** *At 24 months,* there is an intervillous adhesion between Mueller's cells (M) and the newly formed pigment epithelium (P). Note the densely arranged villi (V) of the pigment epithelium and the shorter finger-like (f) projections of Mueller's cells. Beneath the pigment epithelium are the lamina basalis interna (lbi) and the inner collagen layer (Col) of Bruch's membrane; m = mitochondria.

cells display a myriad of delicate apical processes (villi) which mesh with shorter processes elaborated by Mueller's cells. Desmosomes are found between adjacent Mueller's cells, simulating an external limiting membrane, but they are no longer seen between pigment epithelium and Mueller's cells because of the interposition of their respective villous differentiation (Figs. 7.**13,** 7.**14**). The overall evolution of the medium cryosurgical lesion is shown in Figure 7.**15.**

What might this imply? The correlation between the maximum adhesion of the cryosurgical lesion at 12 days and the development of desmosomal connections between the smooth surfaces of pigment epithelium and proliferating processes of Mueller's cells makes it tempting to suggest that remodeling of the lesion, with the displacement of desmosomal connections, might correlate with a late weakening of the adhesion. This conclusion is not justified on the present evidence, because of the lack of uniformity of the lesions and because of the favorable long-term clinical results in treating

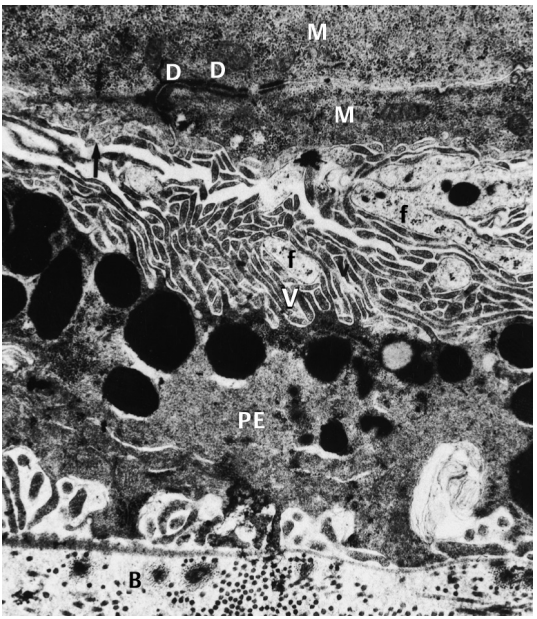
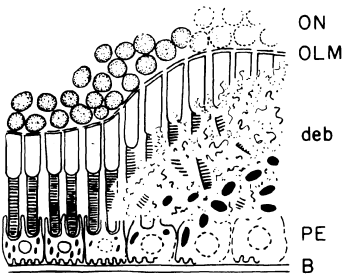


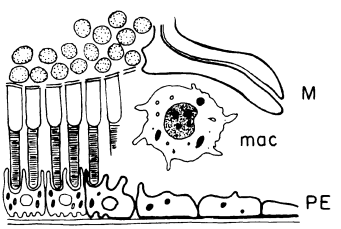
Fig. 7.**14** *At 30 months,* desmosomes (D) are formed only between adjacent Mueller's cells (M). The thin long villi (V) of pigment epithelium (PE) contrast with the short finger-like villi (arrow) of Mueller's cells. Thicker finger-like processes (f) represent processes of histiocyte. B = Bruch's membrane.

detached breaks with cryosurgery and only a temporary balloon buckle [23].

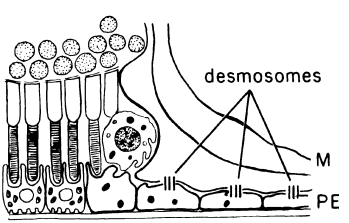
In addition, it should be pointed out that the cryosurgical application causes deeper and more profound necrosis of tissue at the center of the lesion than in the periphery [15]. Remodeling with villous proliferation is therefore limited to those areas in the adhesion in which pigment epithelium has regenerated and recovered Bruch's membrane. However, at the center of lesions produced by moderate applications of cryopexy, there are areas in which the pigment epithelium fails to re-cover Bruch's membrane before Mueller's cell processes come into contact with it. In these areas, Mueller's cell processes secrete a basement membrane and adhere



1. Cryo injury



2. Depolarization and migration of pigment epithelium



3. Migration of Mueller's cells and bonding

Fig. 7.**15** **Five stages of repair and remodeling of cryosurgical adhesion.**

1. *Cryosurgical injury, **1 day** after medium cryopexy application.*
The center of the lesion is at the right. The pigment epithelium, rods, and outer nuclei are necrotic with cellular debris. Bruch's membrane is intact.

B Bruch's membrane
deb Debris
OLM Outer limiting membrane
ON Outer nuclei
PE Pigment epithelium

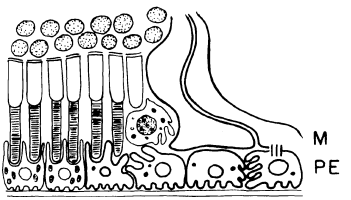
2. *Depolarization and migration of pigment epithelium at **4 days.***
Depolarized pigment epithelial cells are sliding across Bruch's membrane. A macrophage swollen with cellular debris lies above the pigment epithelium. The outer nuclei have disappeared, and processes of Mueller's cells are descending from the retina.

M Mueller's cells
mac Macrophage
PE Pigment epithelium

3. *Migration of Mueller's cells and bonding at **2 weeks.***
Processes of Mueller's cells have filled the defect and attached with desmosomes to the smooth surface of the pigment epithelium.

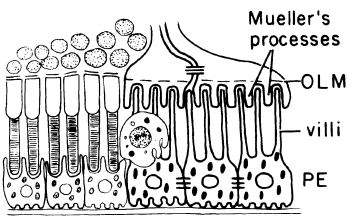
M Mueller's cells
PE Pigment epithelium

4. *Repolarization at **4 weeks.***
The pigment epithelium repolarizes. Basal infoldings are present. Disoriented villous processes appear at the lateral edges.
M Mueller's cells
PE Pigment epithelium



4. Repolarization

5. *Remodeling of the intercellular bond at **2 months.***
Villi of pigment epithelium reorient to the apex of cell and interdigitate with short processes from Mueller's cell processes that protrude through restructured outer limiting membrane (cf. Figs. 7.**12,** 7.**13**) [slightly modified from ref. 22].
OLM Outer limiting membrane
PE Pigment epithelium



5. Remodeling of intercellular bond

to it with hemidesmosomes [20]. At some points, the surface of Bruch's membrane is penetrated by processes of Mueller's cells; these processes distribute in the collagen lamellae of the membrane. There is no evidence of late remodeling in these areas.

- **Even after 3 years**, the hemidesmosomal attachments of Mueller's cell processes and their infiltrations of Bruch's membrane between the collagen lamellae appear to be unchanged.
  In morphological terms, therefore, there is no evidence to suggest any weakening of the adhesions.

7.4 Basic Information for the Detachment Surgeon from Thermal Experiments

We return here to clinical work from the above excursion into the fields of research and electron microscopy. The experiments confirm the clinical impression that cryosurgery produces an adhesion sufficient for the treatment of retinal detachment.

- Reservations concerning the reliability of the cryosurgical adhesion in patients with retinal detachment with much traction are not justified.

The adhesiveness of cryosurgical lesions varies directly with the intensity of the application. In addition, it is possible for the detachment surgeon to select the intensity of the cryosurgical lesion under ophthalmoscopic control and to predetermine the subsequent adhesiveness. With cryosurgical lesions, one therefore has an ability to select the appropriate application for various problems in retinal detachment surgery [17, 24].

- In clinical practice, the following selection of a cryosurgical application is advisable:
  - **A light application** for prophylactic treatment of round holes and areas of degeneration
  - **A medium application** for operculated tears and holes in manifest detachments
  - ***Heavy applications are to be avoided,*** because the residual retina is fragile and subject to tearing if redetachment should occur

By contrast, as will be recalled, it was not possible with diathermy to produce lesions of a preselected strength by monitoring the applications ophthalmoscopically.

The availability of this information about the rapid increase in the adhesive strength of the cryosurgical adhesion encouraged us 25 years ago to introduce earlier mobilization of retinal detachment patients, with discharge after a few days and a return to full activity at the end of the second week.

- Information about the strength of the cryosurgical adhesion at 7 days provided a basis for leaving a scleral buckle only temporarily at the eye when treating a detachment with a balloon buckle (see Part 2: Chapter 9. Temporary Balloon Buckle without Drainage) [24].

In this special procedure, the balloon is removed after 1 week.

? Is there no risk of redetachment when the temporary buckle is removed after 1 week?

▶ No, due to the certainty that at that time the cryosurgical adhesion has become already 4 times stronger than the natural intraretinal adhesion.

If cryosurgery had not been developed, the detachment operation described in the following Chapter, involving a minimal extraocular approach, would not have become possible. Cryosurgery allows appropriately designed surgery. When it is applied adequately, there are considerable benefits for the retina and the patient; however, the eye can also be harmed due to overfreezing, jeopardizing the prognosis of the detachment operation. The variety of retinal scars resulting after various thermal injuries should be borne in mind when treating a detachment, and this information should serve to guide cryosurgery.

- **As a guideline, if you are in doubt about how much cryosurgery to apply (i.e., which intensity), it is better to steer toward less—and this is true of laser coagulation as well.**

A few details can be given here concerning the clinical use of cryosurgery before we go on to the topic of minimal extraocular surgery for retinal detachment (that besides using cryosurgery applies elastic buckles to allow nondrainage of subretinal fluid) in the next Chapter.

7.5 Clinical Application of Cryosurgery (Cryopexy)

7.5.1 Mechanics of the Cryoprobe

First, a few facts about the cryoprobe used: It consists of a plastic insulated pencil-like device with a metallic tip that diverges from the end of the shaft at an angle of 90°. N_2O gas is transferred to the probe and recovered through channels encased in a flexible tube. The cooling effect is obtained by expansion of the gas in the tip of the probe. The temperature at the tip varies with the pressure of the N_2O released from the gas cylinder attached to the console. Pressure is regulated by a knob on the console (Fig. 7.**16**). Working pressures vary between 400 and 625 psi, and yield temperatures at the tip of between –30 °C and –60 °C. The flow is activated by a foot pedal.

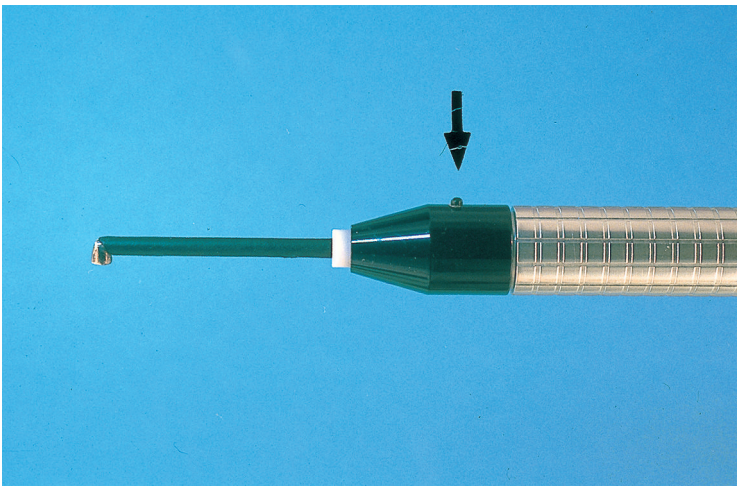
7.5.2 Techniques of Cryosurgery

▶ **Treatment of retinal detachments**

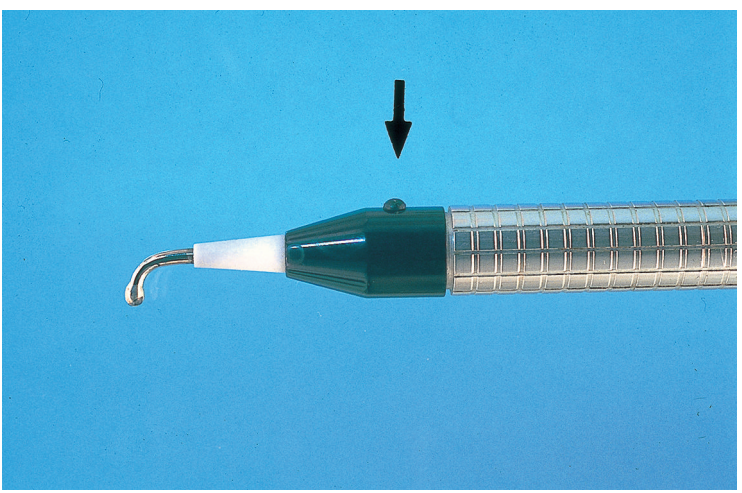
The cryoprobe is applied to the sclera after the conjunctiva has been opened and Tenon's tissue has been dissected in the quadrant or quadrants of the intended treatment. The break is localized by indenting and moving the probe under ophthalmoscopic control from the ora serrata in a radial direction toward the break (to avoid paralactic displacement of the detached break). Indentation by the probe is easily perceived.

- Care must be taken to prevent the shaft from also indenting the sclera.
  - **"Only the tip should touch the sclera"** should be a frequent cautionary advice to the assistant.

Freezing is controlled by the pressure setting on the console and the duration of the application. The working temperature for most adult eyes is –40 ° to –60 °C, which is obtained with a pressure setting of up to 625 psi. The duration of the freeze varies between 2 and 4 seconds. The freezing effect varies with the thickness of the sclera, and to a lesser extent with the vascularity of the choroid. The choroid is largely exsanguinated by the indentation.



a



b

Fig. 7.**16** The cryoprobe is an insulated pencil-like device with a metallic tip (the tip itself is not insulated, since freezing occurs here) that diverges from the end of the shaft. The temperature at the freezing tip is regulated by a knob (arrow) on the console.
a Straight retinal cryoprobe (for anterior retina): the stylette can be shorter depending on the model used.
b Curved retinal cryoprobe (for posterior retina).

- To obtain the optimal lesion (medium), it is necessary to monitor each application ophthalmoscopically.
  - **Do not rely on the appearance of the freeze on the surface of the sclera.**

In the presence of an opaque vitreous due to hemorrhage, cryopexy is ill-advised. However, one should be aware that in most eyes with vitreous hemorrhage, the anterior retina can be visualized by indirect ophthalmoscopy and sufficient depression of the scleral wall.

▶ **Prophylactic treatment**

For anterior retinal tears and to complete a pancoagulation in the diabetic eye, the cryoprobe is applied to unopened conjunctiva. Here, too, each lesion must be monitored ophthalmoscopically. The freezing time at –60 °C will be only slightly longer because of the intact conjunctiva. The conjunctiva will be edematous for 1–2 days after cryopexy. Topical or subconjunctival corticosteroids will reduce the edema. Breaks as far posterior as the equator can sometimes be cryopexied without opening the conjunctiva, by pushing the probe into the conjunctival fornix.

- It is necessary to keep the fornix dry, otherwise the freezing effect is absorbed by the lake of fluid surrounding the tip of the probe.

7.5.3 Using the Cryoprobe to Localize Breaks

? **Does this imply using the cryoprobe as indentor and localizer?**

▶ The cryoprobe is an optimal instrument for localizing breaks in detached retina.

A freeze mark in the retina eliminates parallax, and provides an absolute localization of the break on the sclera. In practice, it is expedient, but helpful for the beginner, to localize the anterior center and then the posterior center of the break and to mark them with ink (methylene blue) or gentianviolet on the sclera. Interrupted

cryopexy can then be applied to the remaining edges of the break (the beginner might be inclined to mark the lateral edges as well).

Multiple applications are separated by approximately half the diameter of the freeze.

? **Contiguous cryopexy is never indicated, and should be avoided. Why?**

▶ To ensure that original retina is still present if redetachment should occur.

Anterior breaks tend to be in relatively shallow detached retina. Indentation with the probe can usually bring the pigment epithelium into contact with, or close to, the retina, so that a moderate freeze appears as a white spot in the retina.

- **Posterior breaks in bullous retina often cannot be reached with the cryoprobe:**
  - **A whitening in the choroid and pigment epithelium** must be accepted for localization of the break. This means that the surgeon needs to correct for anterior–posterior parallax.
    Do not maintain the application and overfreeze in an attempt to obtain retinal whitening.
  - Instead, buckle the break on the basis of the choroidal localization, and **photocoagulate the edges of the break** the next day after the retina has become reattached.

Freezing pigment epithelium alone may provide some adhesion, but a more effective adhesion requires coagulation of the outer retina as well.

- **When localizing a break, do not try to keep the defrosted probe in contact with the sclera when rotating the eye into a position for marking the sclera:**
  - The probe is likely to slip during the rotation, and the apparent indentation mark on the sclera when the probe is lifted will be incorrect.

- **Faulty marking is a frequent cause of buckle failure.**

- Marking errors can be prevented by training an assistant to move the probe as directed by the ophthalmoscopist and to do the marking.

7.5.4 Complications of Cryopexy

These are rare. The probe can perforate thin (blue) sclera. This is an effect of pressure, not of freezing. It should be avoided by examining the area of the sclera before it is treated.

- The best technique again is to have the assistant move the probe while he or she observes the sclera.

Breakdown of the blood aqueous barrier and dispersion of pigment epithelium is a result of excessive freezing. However, the therapeutic freeze should be produced by a medium application (first whitening of the retina).

The mean number of applications for a detachment operation is 6 (4–10).

- **Avoid random freezing of peripheral areas of retina when searching for a break:**
  - Instead, reserve exploratory freezing for the few spots that look suspicious when depressed by the probe.

Now that we are well informed about cryosurgery, we can move on to the next topic—minimal extraocular surgery in the treatment of retinal detachments using cryosurgery and segmental buckling without drainage of subretinal fluid.

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8 Segmental Buckling without Drainage: Minimal Extraocular Surgery for Retinal Detachments

8.1 Principle of the Nondrainage Operation

The nondrainage operation was inaugurated by Custodis in 1953, but this unique technique only met with widespread acceptance after Lincoff modified it in 1965. Replacing diathermy with full-thickness cryosurgery (see Chapter 7, p. 93) and the Polyviol plombe with another elastic plombe, the sponge, the complications of this new procedure were eliminated.

- **Avoiding drainage brought about 2 major changes:**
  1. *A change from intraocular to extraocular detachment surgery.*
     The elastic explant, sutured onto the sclera under tension and compressed by a mattress suture, circumvented the need to drain subretinal fluid and consequently eliminated the need to replace the lost volume (of drained subretinal fluid) by an intraocular injection.
  2. *A change from retinal detachment surgery to retinal hole surgery.*
     The prerequisites for this were the refined fundus examination techniques developed by Schepens, Goldmann, Lincoff and others in combination with scleral depression (see Chapter 2, p. 7), making the entire retina up to the ora visible. There were no more uncertainties in the periphery to be walled away. Instead, the surgical procedure, segmental buckling without drainage, could be limited to the area of the break.

- **Minimal extraocular surgery had thus evolved. In the subsequent years, refinements of the technique followed:**
  - Searching for an optimal tamponade for the break (preferably radial vs. circumferential)
  - Developing a temporary tamponade of the break (the Lincoff–Kreissig balloon) to eliminate the last complications of segmental buckling, i.e., scleral perforation (when placing intrascleral sutures) or buckle-induced diplopia/infection

? How does nondrainage work?

The prerequisites for it are:
1. That all of the breaks have to be found
2. That they are adequately tamponaded by an elastic buckle.

The buckle (sponge) is sutured under tension onto sclera in the area of the detached break, and compressed to half of its volume with a mattress suture. This will cause a rise in intraocular pressure up to the pulsation of central artery (which must be checked). However, intraocular pressure is not static, but dynamic: During the following hour or hours, intraocular pressure will drop to normal levels, and the compressed elastic sponge will expand secondarily, creating a deeper indentation in the globe and thus closing the break, if the buckle is placed correctly. As a result—and only under these conditions—subretinal fluid will disappear postoperatively and the retina will reattach; but it can only reattach completely if all of the breaks were found and adequately buckled. This is the secret (often described as "miraculous") of minimal surgery without drainage. The following section describes how to carry out minimal extraocular surgery without drainage.

8.2 Preoperative Management of Segmental Buckling without Drainage

It is important at the time of surgery to have a detailed fundus drawing of the precise location of the break or breaks to be treated (see Chapter 2, p. 7). It is advisable not only to define preoperatively the clock hour position of a break, but also to estimate its distance from the limbus in millimeters. Once one becomes experienced at this, it proves valuable during surgery when a tiny hole in a detachment needs to be detected, especially if the media is not clear.

The lashes of the eye to be operated on should be cut the night before, and the rim of the lids should be treated with antibiotic ointment (e.g., gentamicin). In addition, the patient should be double patched the night prior to surgery, and the head should be positioned so that the break (or potential breaks) is in a dependent position. An exception to this is when the detachment is accom-

panied by a hemorrhage. When this is the case, elevation of the head by at least 30° is needed to settle the blood inferiorly and provide better visibility during surgery (see Chapter 3, p. 27).

- Double patching for a day will cause flattening of a bullous detachment, making it easier to localize the break. Occasionally, double patching and bed rest may cause a break to reattach, making it suitable for treatment with laser or cryosurgery alone.

- **Prior to surgery, it is advisable:**
  - To check whether the pupil is maximally dilated.
  - To examine the fundus to see whether any significant change in the retinal findings has occurred, and if so, whether the surgery planned the day before will still be the adequate approach.

8.3 Anesthesia

The buckle operation is carried out with local anesthesia. Due to the greater morbidity, retrobulbar anesthesia has recently been replaced by parabulbar anesthesia. But here as well, a blunt needle is used for injection to avoid the hazards of scleral perforation.

General anesthesia is reserved for children and otherwise uncooperative patients. A lid block is not required.

8.4 Instrumentation and Surgical Technique

The instruments prepared for surgery should now be checked (Fig. 8.**1**). As a rule, except for the forceps to grasp the lids and to place the transconjunctival traction sutures, we use flat instruments to avoid unnecessary trauma during surgery.

After the skin has been cleaned and painted with disinfectant, the fornix is irrigated with a dilute antiseptic solution. The face and lid are covered with an adhesive drape; the drape is incised between the lids, and a wire speculum is inserted. A limbal peritomy is

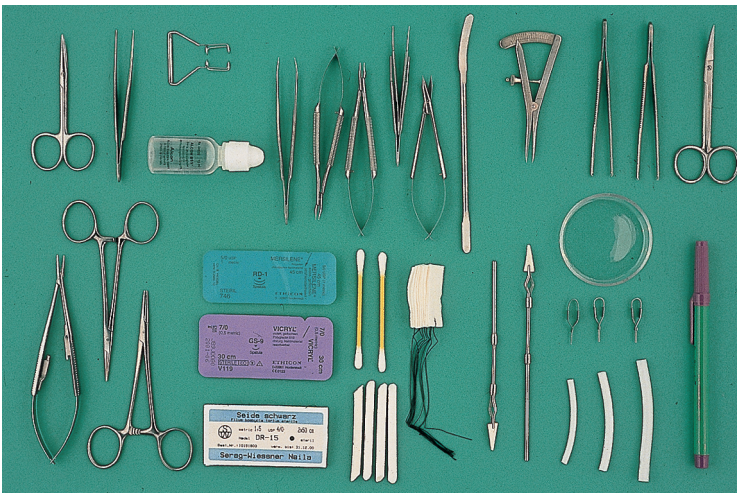


Fig. 8.**1** **Instruments for surgery with segmental buckles.**
Top row (left to right): Bonn strabism scissors, curved (to incise drape); forceps (sharp, for lid sutures, if placed); Barraquer eye speculum; balanced salt solution; Castroviejo forceps (sharp, for transconjunctival traction suture through insertion of muscle); 3 Barraquer needle holders, short (2 straight, 1 curved); Bonn forceps, blunt; Westcot scissors, blunt; Bonn spatula, narrow; Castroviejo caliper; 2 Kreissig siliconized introduction forceps for balloon catheter (in addition to grasp and adapt Tenon's capsule and conjunctiva with minimal trauma prior to suturing); Bonn scissors, curved (sharp, to cut or incise sponge).
Bottom row (left to right): needle holder (for lid sutures, if needed); 2 hemostats (to fixate lid sutures, if placed, on drape), double-armed Rd-1 Mersilene suture or 5–0 Dacron with spatula needles; Vicryl suture (absorbable) or silk suture for conjunctiva. To keep operating field dry: Q-tips; so-called "cigars"; brain swabs (swabs with black thread, used in brain surgery, to cover rim of lid and area of cut lashes to avert contact and infection of the sponge during its placement and fixation); triangle swabs on metal holder; 3 safir clamps (if at all used); cylindrical sponges 4 mm, 5 x 5 mm or 5 x 3 mm, 7.5 x 5 mm; scleral marker.

made of 1 1/2 clock hours in extent on either side of the break, or longer if the area to be buckled is larger. The limbal peritomy is enlarged at either end by a meridional incision about 5–7 mm long in both the conjunctiva and Tenon's capsule (Fig. 8.**2**). Traction sutures

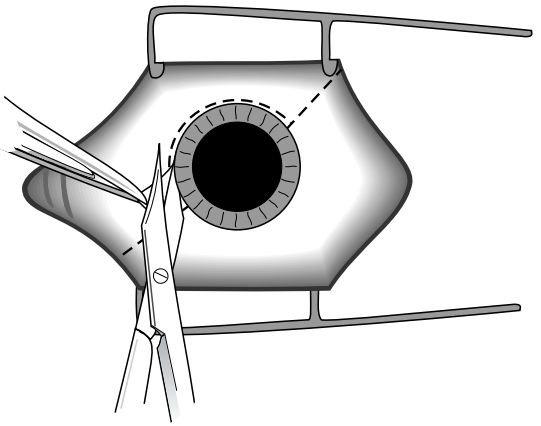


Fig. 8.**2** The limbal peritomy (8 o'clock over 12 to 1 o'clock) is combined with 2 radial incisions (at 8 o'clock and 1 o'clock) through the conjunctiva and Tenon's capsule, enlarging the exposure of the surgical field and thus preventing subsequent tearing of tissues when retracted during surgery.

are placed beneath the 4 horizontal muscles. In unopened conjunctiva, they are placed transconjunctivally as anteriorly as possible in the area of the tendon's insertion.

? Why?

▶ The extreme anterior position of the traction sutures avoids bleeding from the muscle and unnecessary dislocation of the conjunctiva when these sutures are pulled on to rotate and stabilize the eye.

The cryosurgery unit should be set at –40 °C to –60 °C at the tip of the probe (see also Chapter 7, p. 93). **The thin cataract probe should not be used** (it is associated with risks in the presence of staphylomatous sclera), but rather the thicker probe for retinal surgery (Fig. 7.**16**).

The cryoprobe should be tested before it is used. An ice ball should form at the tip, leaving the shaft spared (since it is insulated). This is to insure that the surrounding tissues are not frozen. During surgery, **every cryosurgical application should be moni-**

tored with ophthalmoscopy and stopped the moment the desired freeze appears.

? What should be done at the time of surgery if the pupil is not as widely dilated as it was preoperatively when the retina was studied?

▶ Surgery should not be started; one should wait until the pupil is optimally dilated.

? Why?

▶ Because the key to atraumatic and precise surgery of short duration is optimal visualization.

Topical sterile phenylephrine (Neo-Synephrine) 5% can help, but in an elderly patient it may cause an abrupt rise in blood pressure. An alternative that is more effective is to have sterile cocaine 5% or phenylephrine 5% in a syringe with a 30-gauge needle and to insert the needle near the limbus under the conjunctiva, preferably at the clock hour position at which the pupil should be maximally dilated. **There is usually no need to inject, as the mydriatic in the needle tip is already sufficient, and after 5–10 minutes the pupil will dilate without systemic side effects.**

The surgeon should localize the detached break from a position 180° across from the area of the break, with the cornea in a horizontal position, and can rotate and stabilize the eye with the 2 traction sutures across the break.

- **The assistant must make certain that only the tip of the probe is in contact with sclera for every freeze.** This will avoid misinterpreting an indentation by the shaft as one caused by the tip.
- Mistaking the indentation of the shaft for the tip can be a serious complication, because the tip would be more posterior, and when cryotherapy is applied it could cause a freeze at the posterior pole.

The assistant also has to keep the parabulbar space dry, to prevent freezing the surrounding fluid and consequently the neighboring tissues.

- The assistant is now asked to place the probe first in the clock hour of the break at the ora, then to orient the tip of the probe vertical to the sclera, and only after that to move it posteriorly in a radial direction toward the break.

In highly bullous detachments, it is very difficult to localize the break, due to the radial and circumferential parallax that is present.

? What to do?

- To eliminate the circumferential parallax, the surgeon needs only to align himself or herself and the gaze at 180° across from the break while the cornea is in horizontal position and not tilted.

Correcting for radial parallax requires greater skill. The anterior edge of a highly elevated break can often be localized with some certainty, although a freeze may not reach the retina. Do not continue to freeze and overfreeze the choroid. Move the probe posteriorly until the depression is seen through the break. One then adjusts to the probable position of the posterior edge of the break. In this special situation it might be helpful to mark the lateral edges of the break, as well as its anterior and posterior ends. This will help in the selection of the appropriate explant. The remaining lateral edges of the break can be treated at the same time with interrupted lesions if the freeze reaches them without overfreezing. Otherwise one should wait, and apply laser after the retina is flat on the buckle.

- **With regard to the posterior edge of a posterior break, it should be borne in mind that the more posteriorly a break is localized, the easier it is to overestimate its posterior location.**
  - If you are still in doubt about the posterior edge, add another 1 mm to the posterior mark of the break, which will be sufficient (at this point it should be borne in mind that the diameter of the disk measures 1.5 mm).

This will become self-evident after the mattress suture has been tied. At that time it is necessary to evaluate whether the buckle is correctly positioned under a highly detached break. The position of the buckle depends in large measure on the precise marks on the sclera made by your assistant and correct positioning of the mattress suture. If you are uncertain, it is helpful to indent the anterior portion of the tied buckle with the closed tips of the blunt forceps.

- **If the buckle is supporting the anterior portion of the break sufficiently, it can be concluded (taking into consideration the posterior position of the suture that has been placed) that the posterior part of the break will be tamponaded as well.**
  This is so despite the fact that the break is still elevated above the buckle, and you are actually looking through the break.
  - At this point you also should remember that about **90% of all breaks are not larger than 1 disk diameter.** This is the reason why, prior to surgery, you should estimate the size of the break (on the scale of disk diameter) to be treated.

The mattress suture (5–0 Dacron or Rd-1 Mersilene with 2 spatula needles) should be placed symmetrically on either side of the anterior and posterior localizing marks, and should overlap the 2 lateral marks by 1–2 mm. The distance between the 2 limbs of the mattress suture defines the diameter of the sponge to be selected. This distance should equal half the circumference of the sponge—i.e.,

- **6 mm distance would require a 4 mm sponge,**
  8 mm distance a 5 mm sponge,
  10 mm distance a 7.5×5 mm sponge,
  14 mm distance 2 overlapping 7.5 x 5 mm sponges
  (Table 8.**1**, Fig. 8.**3**).

Table 8.1 Size of retinal break in relation to diameter of radial sponge cylinder and width of mattress suture.

Retinal break	Radial sponge	Width of mattress suture
2 mm	4 mm	6 mm
3 mm	5 mm	8 mm
5 mm	7.5 (x 5) mm	10 mm
8 mm	two 7.5 (x 5) mm	14 mm

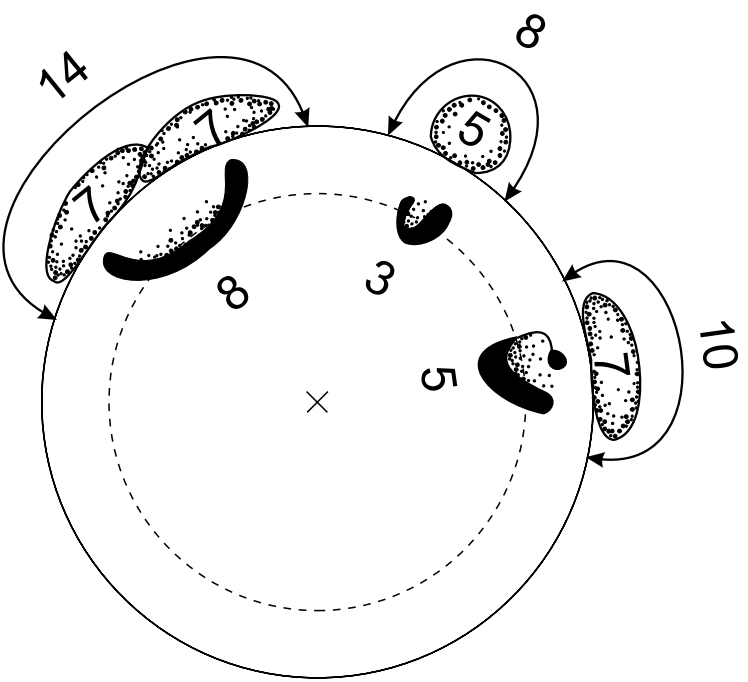


Fig. 8.3 Diameters of sponge cylinders used to tamponade breaks of various sizes, with the widths of the compressing mattress suture (drawing according to H. Lincoff, M. D.).

? The mattress suture should be made with long intrascleral limbs (6 mm), not using multiple sutures with short intrascleral passages. Why?

▶ Because short sutures tend to tear out when tying over the sponge under tension (one of the causes of buckle extrusion).

When the orientation of the sponge is being selected, a radial position is preferable, since it will provide more adequate tamponade for both the anterior and posterior portions of the break. The rationale for it is discussed below (see Chapter 8.5, Orientation of Segmental Buckle, p. 138). Before the sponge is tied onto the sclera, a smear of the surgical field should be taken and sent for culture to microbiology.

? How do you tie a sponge under tension when its posterior suture is too posteriorly located to be tied properly? What should you do?

▶ In this situation, it is helpful first to knot the 2 free posterior ends of the mattress suture after cutting off the 2 spatula needles, and then pull the suture anteriorly, checking that the knot is positioned in the center of the sponge. Then cut the closed anterior loop of the suture, and tie the 2 anterior ends under tension over the sponge (Fig. 8.**4**).

? How can one avoid posterior or anterior slippage of the suture off the buckle, especially after trimming the sponge?

▶ A shallow cut at the ridge of the sponge will trap the suture.

By this maneuver you can achieve the required compression of the explant when tying a very posteriorly placed mattress suture.

? What is important after tying the suture or sutures?

▶ Check the central retinal artery for patency.

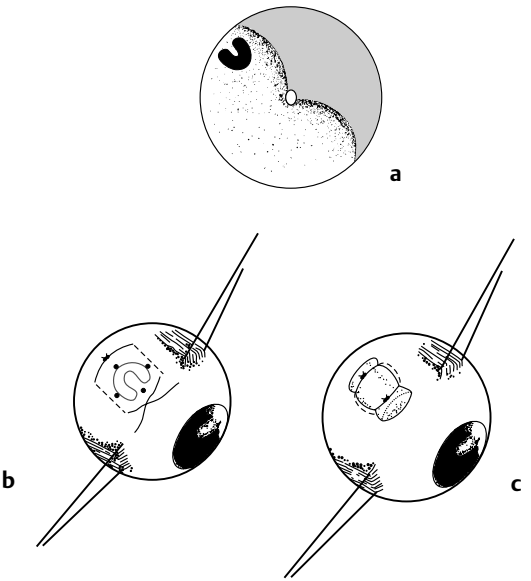


Fig. 8.4 **Minimal extraocular detachment surgery.**
a Superior lateral detachment, with a horseshoe tear at 10:30.
b The tear, localized by marks on the sclera, is treated with cryopexy and surrounded with mattress suture centered at the plotted radian of the tear.
c The sponge cylinder is compressed by mattress suture tied over the tear. On the need for a posterior knot in addition to the anterior one, see the text p. 135.

Compressing the elastic silicone sponge against the sclera will raise the intraocular pressure. If the central artery is closed, digital massage of the eye will accelerate reopening of the artery. Most arteries will begin to show pulsation in 2–3 minutes. If there is no sign of pulsations within 5 minutes, a tied suture can be reopened (when tying several sutures it is therefore helpful to tie a temporary knot, which is easy to reopen) or part of the compressed sponge can be pushed back under the tied suture. However, if there is still no sign of pulsation after another 5 minutes, the eye is probably one with poor outflow, and paracentesis or drainage of subretinal fluid is indicated.

When multiple sutures are being tied for an extensive buckle, it may be necessary to check the central retinal artery for patency after each knot, and only proceed to tie another one if the artery is completely open. We practically never resort to intravenous acetazolamide or mannitol, because they work too slowly and have only a minimal effect. Later they even may potentiate postoperative choroidals.

? Avoid drainage whenever possible. Why?

▶ Because the choroid is probably congested (after localization of the break, cryosurgery, suturing, etc.) and perforation for drainage may provoke a hemorrhage.

? How can buckle extrusion and secondary infection be avoided?

▶ A buckle extrusion is a result of traumatic surgery, such as intraoperative trauma to the conjunctiva, or it can be due to superficial or short intrascleral mattress sutures. It can even be caused by suturing of the conjunctival edges under tension.

● **During the entire operation, it is therefore mandatory:**
- **To avoid grasping the conjunctiva with sharp instruments.** This can easily be achieved if only flat forceps are available during surgery (Fig. 8.**1**) and if every effort is made to avoid touching the conjunctiva.
- **When the eye has to be rotated,** it should not be done by grabbing the tissue with instruments.
- **Traction sutures should be used, instead.**
- **Trauma to the conjunctiva can also occur from excessively vigorous swabbing to remove fluid** and blood from the surgical field, or at the time of freezing.
- **Instead, fluid or blood should be swabbed at a distance, i.e., if possible without touching the tissues**.

All of these precautions have to be taken to protect the conjunctiva, which is necessary for a secure closure over the explant.

If the buckle is in the correct position, and if the central artery is pulsating or reperfused, closure of Tenon's capsule and the conjunctiva can be started with a running suture (with absorbable material or silk). The 2 meridional incisions up to the limbus are closed. At the limbus the conjunctiva only has to be adapted to the cornea, and does not require suturing. Prior to closure, the surgical field is rinsed with an antibiotic solution (e.g., gentamicin). The antibiotic solution in which the sponge was soaked during surgery can be used.

- **At the end of surgery,** the pulsation of central retinal artery has to be checked again by ophthalmoscopy, and this time also the intraocular pressure exactly measured (e.g., with a Schioetz tonometer, which is easy to sterilize), because it may still be increased. **This is mandatory prior to patching.**

Before patching the eye, mydriatic (atropine 1%) and antibiotic (gentamicin) ointment is generously applied. The fellow eye was covered prior to surgery. Special positioning may still be necessary if there is an intraocular hemorrhage. Double patching is maintained until the next morning. If the breaks are flat on the buckle or the retina has reattached, the fellow eye is unpatched. The subsequent treatment consists of topical application of mydriatics and the antibiotic that was applied at closure of surgery. No systemic antibiotics are required.

8.5 Orientation of the Segmental Buckle

The retina is fixed at the ora serrata and the disk. When detaching, it tends to form radial folds. A circumferentially orientated buckle would therefore augment or at least preserve the radial folds by shortening the circumference of the globe and thus causing surplus retina in a circumferential direction. The resultant radial folds tend to aggregate, and most of the time align with the retinal break, causing what is termed "fishmouthing" of the retinal break (Fig. 8.**5 a**). The fishmouthing, in turn, provides a path for vitreous fluid to enter the subretinal space, causing failure.

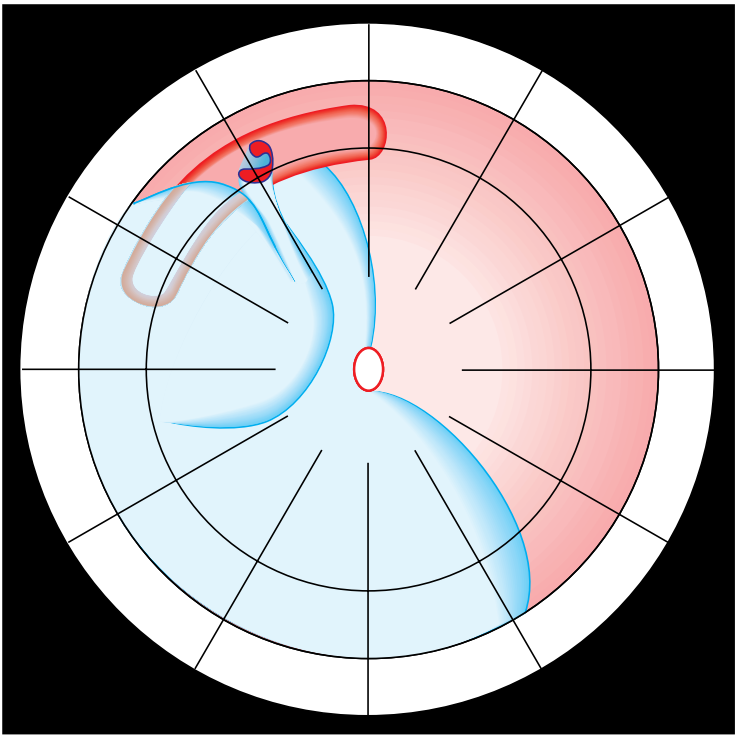


Fig. 8.**5 a** Inadequate tamponade of horseshoe tear in detachment. The horseshoe tear at 11 o'clock is supported by a circumferential buckle extending over $2^1/_2$ clock hours. The tear is supported anteriorly, but posteriorly it is leaking due to a fold causing "fishmouthing." Without drainage, the retina did not reattach; there is only a minor change in the anterior border of the detachment.

? How can we prevent fishmouthing of a retinal break?

▶ A logical approach is to fill the potential fold at the posterior edge of the horseshoe tear—i.e., filling it by providing a radial buckle as a tamponade (Fig. 8.**5 b**).

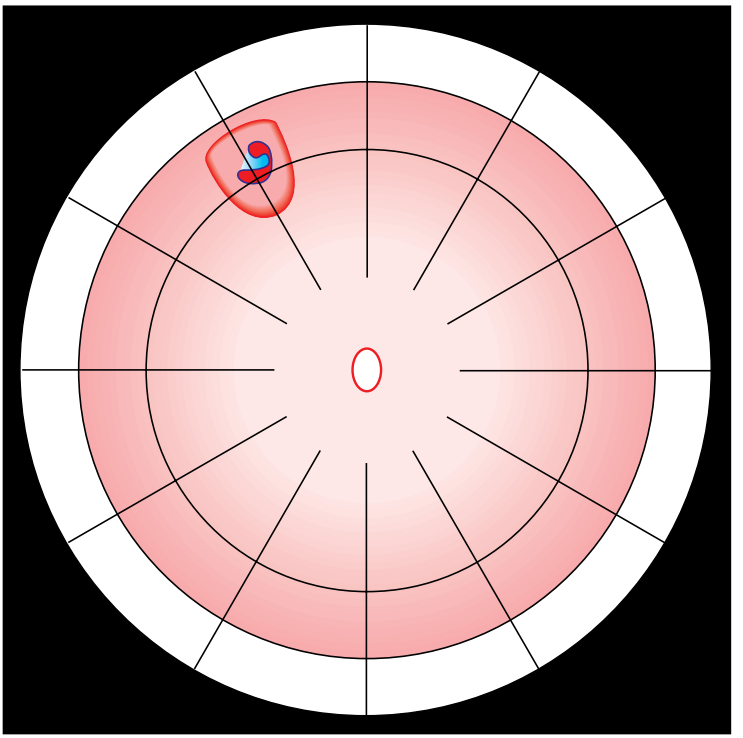


Fig. 8.5 b Adequate tamponade of horseshoe tear in detachment of Fig. 8.5 a. The tear at 11 o'clock is supported in this instance by a radial buckle that provides adequate tamponade of the horseshoe tear—i.e., anteriorly and posteriorly. The horseshoe tear is positioned on the ridge of the buckle, and the retina reattached completely without drainage.

? What are the advantages of a radial buckle [1]?

▶ **A radially orientated buckle** (Fig. 8.6):

1. Places the entire break on the ridge of the buckle
2. Counteracts fishmouthing of the break, i.e., the risk of posterior leakage
3. Provides optimal support for the operculum, i.e., counteracts future vitreous traction with the risk of anterior leakage.

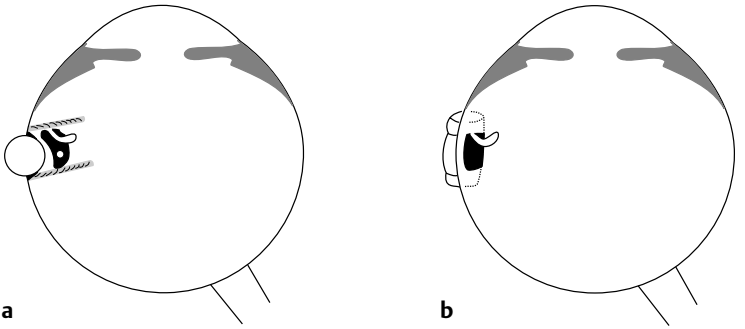


Fig. 8.6 Tamponade of a horseshoe tear.
a Using a *circumferential buckle,* the horseshoe tear is not tamponaded adequately: The operculum, the area of future traction, is not on the ridge of the buckle, but on the descending slope. In addition there is a risk of posterior radial folds, with subsequent leakage.
b A short *radial buckle* provides optimal tamponade for a horseshoe tear: The entire tear is placed on the ridge of the buckle, i.e., this counteracts fishmouthing of the tear (avoiding risk of posterior leakage) and provides optimum support for the operculum (counteracting future vitreous traction).

- **Therefore, whenever possible, the sponge should be orientated with its long axis in the radial direction of the break.**
  - Several radial buckles can be used, but the breaks have to be separated by at least $1^1/_2$ clock hours.

If the breaks are closer to each other, a circumferential buckle has to be used. However, it should be borne in mind that:

- **The greater the length of a circumferential buckle, the more radial folds will result.**
  - Therefore, the shorter the circumferential buckle, the safer it is.

On top of this, in order to achieve adequate tamponade of a horseshoe tear using a circumferential buckle, special precautions have to be taken when localizing the anterior and posterior edge of the

break, so that the break is supported sufficiently, making sure in particular that the operculum is not placed downward.

Another aspect to remember is that when a circumferential buckle is close to the ora serrata, where the retina is anchored, it is likely that the resulting radial folds will be small and evenly distributed.

● **However, when a circumferential buckle is far away from the ora serrata, at or posterior to the equator**, the chance that small folds will aggregate into a larger one is greater, and most of the time this will lead to the posterior edge of the tear causing **fishmouthing** with leakage.

? **What should be done if the buckle is interfering with a rectus muscle?**

▶ Always give **priority to optimal tamponade of the break**, over the risk of eventual diplopia being caused by the buckle (see binocular motility exercises after surgery, pp. 143–144).

? **But how can the risk of diplopia be circumvented primarily?**

▶ First of all, never traumatize the perimysium of the muscle during surgery, and do not grasp it with sharp instruments.

? **How should one proceed when a *radial* sponge has to be placed in the meridian of a rectus muscle?**

▶
- If the sponge is only partly interfering with the muscle, resect the muscle and move it to either side of the explant.
- If the sponge is centered on the muscle, resect the muscle, bluntly split it in a radial direction into 2 portions, and resuture 1 portion to either side of the explant.

– In recent years, we have placed short and very anterior radial buckles even on top of the rectus muscle and its insertion, but **the patient has to be instructed to carry out repeated binocular exercises daily during the first 2 weeks after surgery to counteract muscular adherences with resulting diplopia** (see below).

? How should one proceed when a *circumferential* buckle has to be placed in the area of a rectus muscle?

▶ – If the explant is anterior, i.e., at the muscle insertion, place it on top of the rectus muscle (e.g., oral disinsertion). Again, don't forget postoperative motility training!
– If the explant is more posterior, allow it to pass beneath the rectus muscle.

? What should be done when a sponge is intruding onto an *oblique* muscle?

▶ – In this situation, the insertion of the oblique muscle is a lesser problem.
– Explants can even be sewn over the insertion of the muscle.
– Or, if they are located more posteriorly, the oblique muscle can be split and a small explant sutured beneath it.

● However, independent of the postoperative state of the retina, **after every sponge operation and starting on the 1st day postoperatively, the patient has to practice binocular motility exercises in all directions daily 5–10 times for about 3 minutes.** This should be explained carefully to the patient, and the nurses should be instructed appropriately.

? Why do we do this?

▶ **To avert** the development of muscular adherences to the sclera or neighbouring tissues—i.e., **to avoid postoperative diplopia**.

Since we introduced this regimen, the rate of postoperative diplopia has fallen to practically zero, despite that buckles are sometimes quite large.

8.6 Application of Nondrainage

As described above, we only tamponade the retinal break, and since drainage is not used, we only have to buckle the area of the detached break with an elastic plombe (a sponge or a temporary balloon) compressed onto the sclera. We can begin here by describing treatment with sponges sewn onto the sclera.

It should be borne in mind, however, that when only 1 break is present in a detachment, a temporary balloon buckle without a fixating suture and without drainage would represent the maximum of a minimal extraocular operation. This operation requires greater skills on the surgeon's part and sufficient experience in localizing a detached break with indirect ophthalmoscopy and is described later (see Part 2: Chapter 9. Temporary Balloon Buckle without Drainage).

? How should one proceed when starting with segmental buckling and without drainage?

▶ To acquire confidence with this technique, progress should be made step by step in order to avoid failures among the first patients treated.

8.6.1 Small Detachment

First, select a small detachment (one that is not too bullous) with a break that is not too small (so that it can be found without difficulty during surgery), but also not too large, e.g., less than 2 disc diameters (so that one can be certain no problems will occur in providing adequate tamponade).

Figure 8.**7 a** shows an example of this type of detachment of

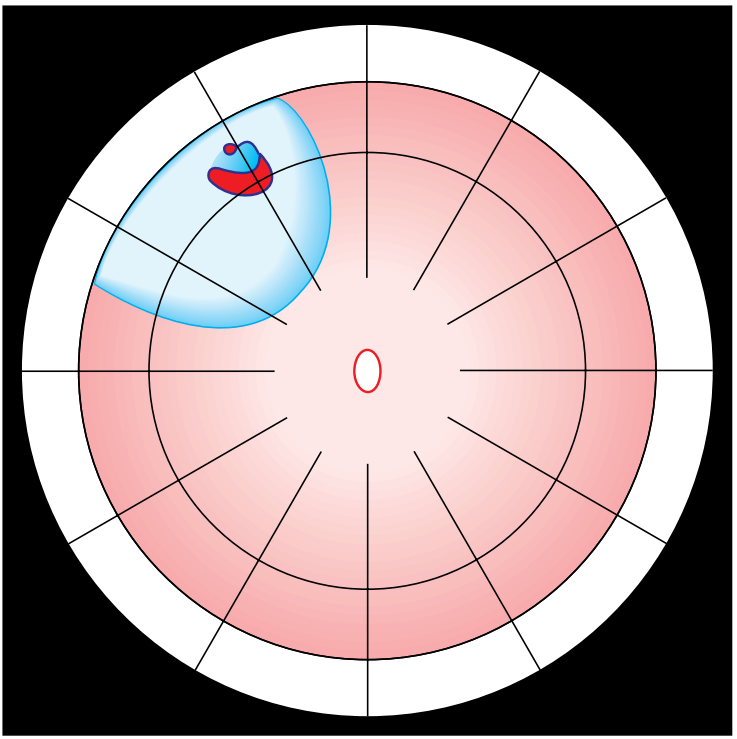


Fig. 8.**7 a** A small detachment. The cause of detachment is the horseshoe tear at 11 o'clock.

less than 1 quadrant in extent, with a horseshoe tear smaller than 2 disc diameters at 11 o'clock. The break will be buckled with a 5 mm radial sponge tied onto the sclera with 1 mattress suture. Do not forget to check the central retinal artery for pulsation. At the end of the operation the break will be still detached—but there is no need to worry. Remember that in this small detachment another break could hardly have been missed. The break that has been

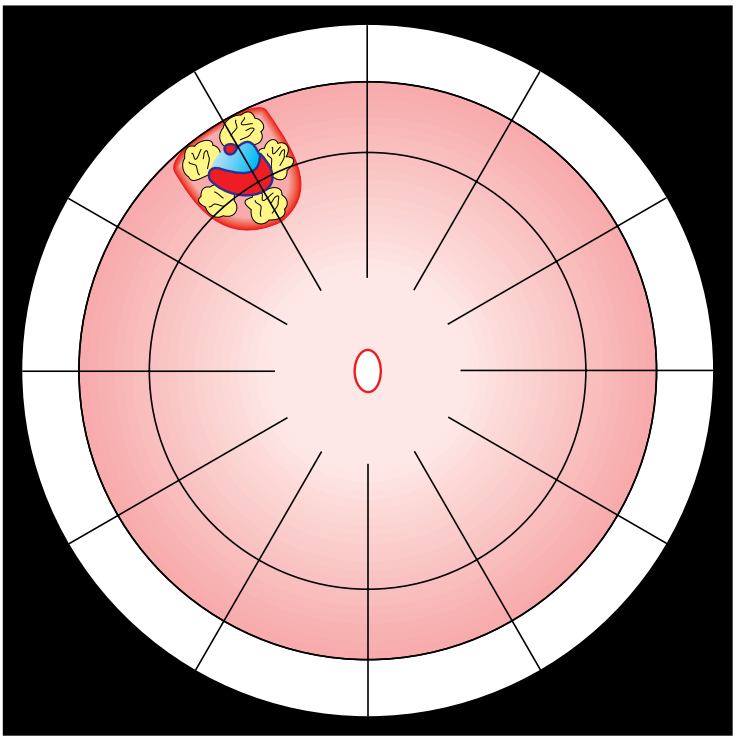


Fig. 8.7 b After tamponade of the tear (with a radial sponge or balloon) without drainage, the retina reattached. Coagulation around the break was carried out intraoperatively by cryopexy, but it is also possible to apply laser after reattachment.

buckled was not highly detached, and it was also buckled generously using a 5 mm radial sponge.

The next morning, there will be relief and at the same time the proof of the quality of the surgery.

- **The break and the retina will have spontaneously reattached (Fig. 8.7 b), confirming:**
  1. That you did not overlook another break
  2. That the horseshoe tear was buckled sufficiently.

From another point of view, this also demonstrates the *potential value of undrained subretinal fluid*. What does this mean?

- It can provide a means of evaluating the quality of surgery.
- **If the subretinal fluid has disappeared spontaneously by the following morning, it provides certainty that the retina was treated correctly,** i.e., that all of the breaks were found and tamponaded sufficiently.
- The retina is definitely reattached, and **the patient can be mobilized without restrictions.**

8.6.2 Extensive Bullous Detachment

After this favorable initial experience without drainage, you will have enough confidence to go on to treat a more extensive detachment, which also has a break at 11 o'clock (Fig. 8.**8 a**). This might in fact even be the small detachment just discussed (Fig. 8.**7 a**), which after a further 4 days later has extended to 3 quadrants and become bullous.

Is there any justification or "indication" for drainage here?

Why, because you are confronted with a bullous and more extensive detachment?

No.

It should be recalled that the rationale for treating this 3-quadrant detachment is still the same as in the 1-quadrant detachment, i.e., the aim is to buckle the break at 11 o'clock that is causing this type of detachment (Fig. 8.**8 b**). Admittedly, this time the localization of the break, which is more elevated, is slightly more difficult, and the detached area in which the presence of additional breaks needs to be excluded has become larger. But this should not be a reason for moving on to a "larger" operation, i.e., draining or selecting a larger buckle.

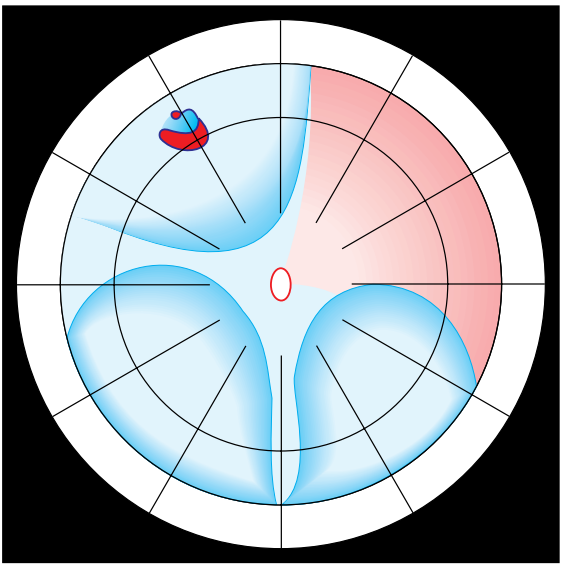


Fig. 8.**8 a** Extensive bullous detachment. This is actually the same detachment as in Fig. 8.**7a,** but it has in the meantime progressed to cover 3 quadrants. The cause of detachment is the same, the horseshoe tear at 11 o'clock.

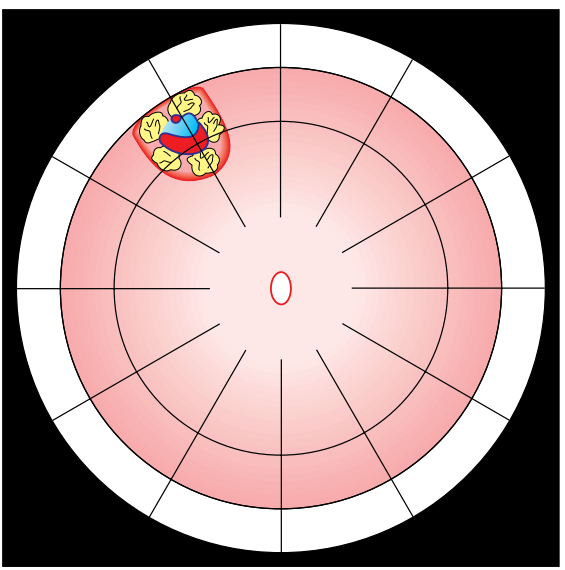


Fig. 8.**8 b** After the tear at 11 o'clock had been buckled with the same tamponade as in Fig. 8.**7b,** the retina reattached without drainage.

- One should thus not allow uncertainties regarding a more extensive detachment to lead one into extending the operation.
  If there are still any uncertainties about the retina, the operation can be postponed for another day and the eye can be re-studied (see Chapter 4, p. 41). This is a far better solution for the eye in every way than carrying out a primary "larger" operation or risking failure and a need for reoperation.

8.6.3 Total Detachment

In Figure 8.**9 a,** we are confronted with a total detachment in an aphakic eye that is very bullous. First of all, the patient should undergo double patching and lie flat for a day. If the retina shows some wrinkling the next morning, it indicates that the bullous quality has slightly decreased. The retina should be studied again carefully, to provide certainty that there is only the 1 horseshoe tear at 11 o'clock. The red spots at 2:30, 7, and 8 o'clock prove to be preretinal hemorrhages at the vitreous base, confirmed using biomicroscopy and depression.

? **How should one treat this total detachment with 1 break and so-called "traction lines"?**

? **Would you move on to a cerclage or a primary vitrectomy?**

▶ First, consider using a smaller-scale solution, tamponading the break.

Buckle the break at 11 o'clock with a radial 5 mm sponge, without drainage. At the end of the operation, of course, the retina is still highly detached. Assuming that another break was not overlooked and that the buckle is providing adequate tamponade for the break, the retina will be reattached the next morning. And this is in fact what happened, except for a small circular convex detachment in the periphery between 5 o'clock and 7 o'clock; the macula is reattached (Fig. 8.**9 b**).

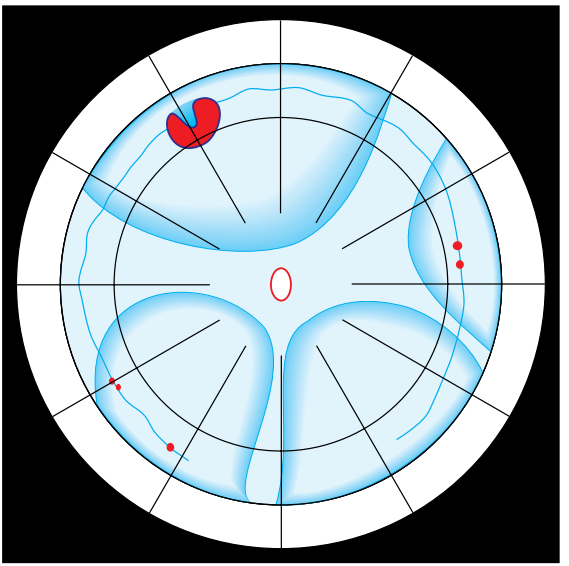


Fig. 8.**9 a** Total aphakic detachment. This detachment, with a horseshoe tear at 11 o'clock, might originally have looked like the one in Fig. 8.**7a,** but has now become total. In the periphery, there are what are known as "traction lines", which in reality represent adhesions of the vitreous base, with some accompanying small hemorrhages. This is a very bullous detachment, due to the fact that it originates from a superior break.

? What will you do now? Is this a failure?

▶ No.

The circular quality of the inferior detachment demonstrates that it is a residual detachment, which actually disappeared after another 2 days Fig. 8.**9 c**).

? What do you have to do during this time?

▶ You should ask the patient to sleep with the head elevated. This avoids the risk of subretinal fluid pooling into the macula overnight (see Chapter 8.13, p. 212).

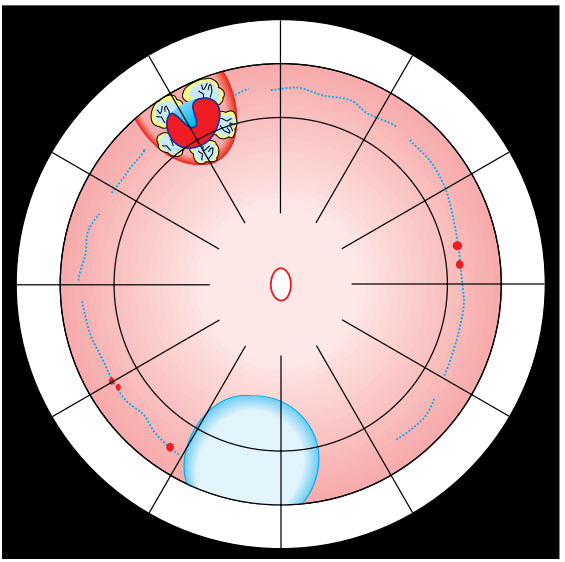


Fig. 8.**9 b** 2 days after the tear at 11.00 had been buckled with a radial sponge (use of balloon is also possible), the retina reattached. In the periphery, adhesions of the vitreous base are still visible, although they are now less distinct. Inferiorly, there is a residual detachment, typified by its circular curvature toward the ora.

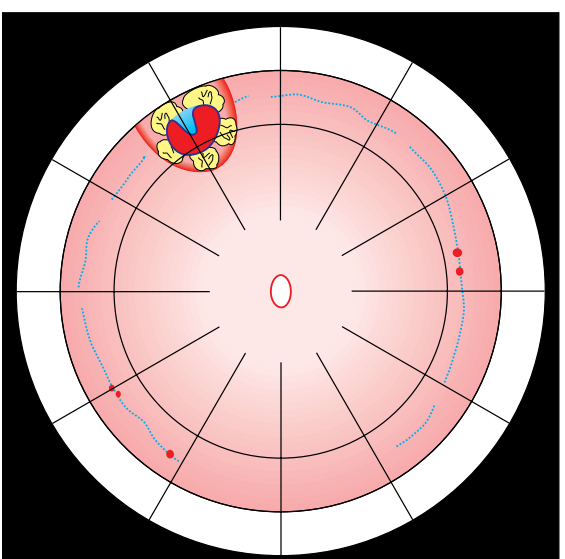


Fig. 8.**9 c** One week postoperatively, the residual fluid has disappeared, and the cryopexy lesions around the horseshoe tear have become pigmented.

8.6.4 Uncertain Localization of a Posterior Break in a Bullous Detachment

The detachment in Figure 8.**10 a** only extends over 2 quadrants, but the break is posterior to the equator on a high bulla. It will be very difficult to localize this hole without drainage during surgery.

? What should be done?

▶ It is advisable at first for the patient to undergo double patching and to lie flat for a day. In many instances, the retina will partially settle, and localizing the hole will become less of a problem.

However, if the retina is still as bullous as in Figure 8.**10 a** at the operating table, an attempt should be made to proceed as follows. Position yourself at 5 o'clock, i.e., exactly 180° across from the hole at 11 o'clock. The posterior hole on the bullous detachment is very difficult to localize, since the retina is widely separated from the choroid and the problem of parallax is very much greater than we have previously seen.

Anterior holes do not present this problem—the retina cannot separate as much, since it is fixed at the ora. The cryoprobe can therefore indent the sclera almost to the point of contact with the retina, allowing one to confirm the localization with a freeze mark in the retina at the edge of the break.

On the other hand, this posterior hole on a bulla may make it necessary to rely on a freeze mark in the choroid and to take parallactic displacement into account to estimate its position on the retina (see Chapter 2, p. 7).

● Moving with the cryoprobe from the ora in a radial direction posteriorly toward the break provides certainty that there is no circumferential displacement, and that one is within the correct radian of the break.

However, there is some uncertainty about how far posteriorly the sponge should be placed.

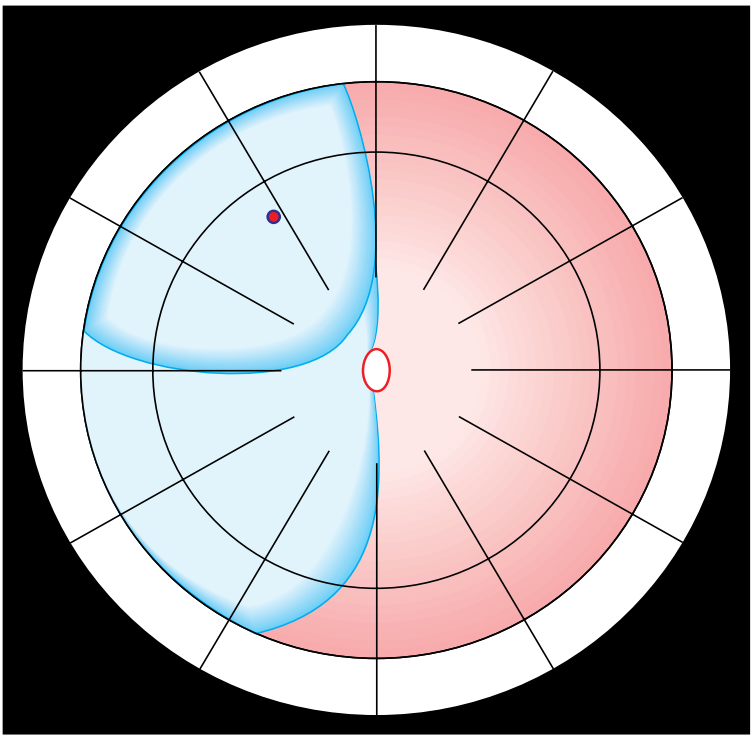


Fig. 8.**10 a** Bullous detachment with a posterior break. The break at 11 o'clock is posterior to the equator on a high bulla, and is difficult to localize without drainage. This is due to the parallax in radial and circumferential directions. After double patching for 1 day with the patient lying flat, the detachment became only slightly less bullous.

When there is uncertainty concerning localization, one should:

- Either buckle the hole and add a partial drainage to ensure that the hole will fall on the buckle (bearing in mind the complications associated with drainage, even if it is only partial).
- *A better alternative*, one can enlarge the radial mattress suture for another 1 mm posteriorly, i.e., *enlarging the radial buckle in the posterior direction* (Fig. 8.**10 b**). This is done to ensure that the break is tamponaded, and it also avoids the need for partial

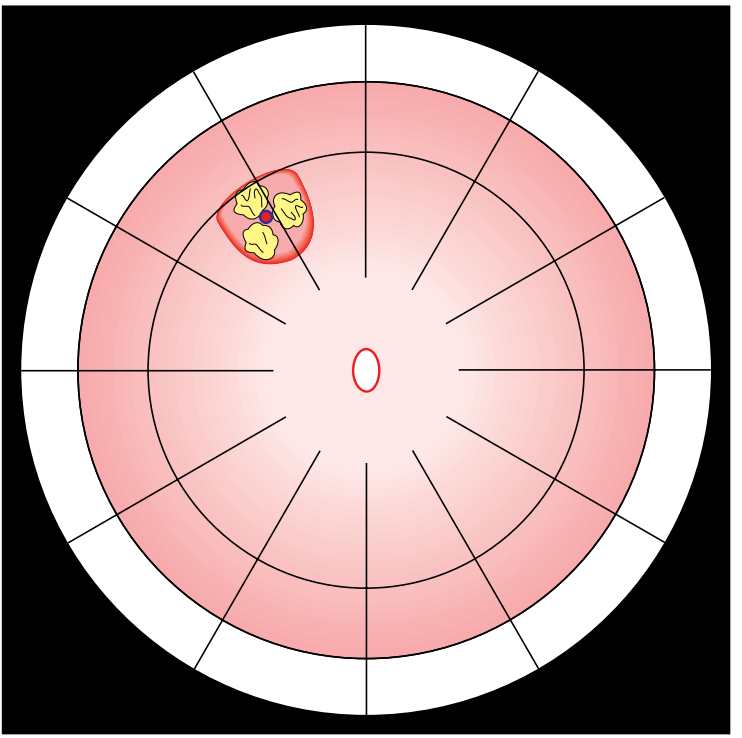


Fig. 8.**10 b** Retina 1 week after radial buckling without drainage. The break has settled on the buckle, and the cryopexy lesions around the break have become pigmented.

drainage. However, one should also recall that **often the buckle for a posterior break is placed too posteriorly.**

- **In our view, there is less morbidity involved in enlarging a sponge in circumferential or even radial direction for another 1 mm, eliminating the need for drainage with its complications or the risk of reoperation.**
  - However, if you are familiar with the balloon operation (see Part 2: Chapter 9. Temporary Balloon Buckle without Drainage), a **balloon buckle would be the preferred method for treating this bullous detachment with a posterior hole.**

? Why?

- This is because firstly, it avoids the difficulties of placing a posterior scleral suture.
- In addition, even after surgery the volume of the balloon can still be increased (by injecting additional fluid via the catheter), thus increasing the height and extent of the balloon buckle to some degree.

When a sponge is sewn onto the sclera in this detachment instead, the buckle has to be very voluminous to provide enough indentation to close off the highly detached break.

As we have just seen, even a bullous detachment or a very extensive detachment do not provide indications for drainage.

Not using drainage avoids the risk of hemorrhage, choroidals, incarceration of the retina or vitreous, and the need to replace lost intraocular volume using an intraocular injection or a more extensive buckle.

8.6.5 Old Detachment

? How do we know that the detachment in Fig. 8.11a is an old one?

It has the following characteristics:

1. Presence of a pigment demarcation line
2. Cysts in the retina
3. Atrophic, thin retina
4. Sometimes “precipitates” on the posterior retinal surface, showing that it is a long-standing condition.

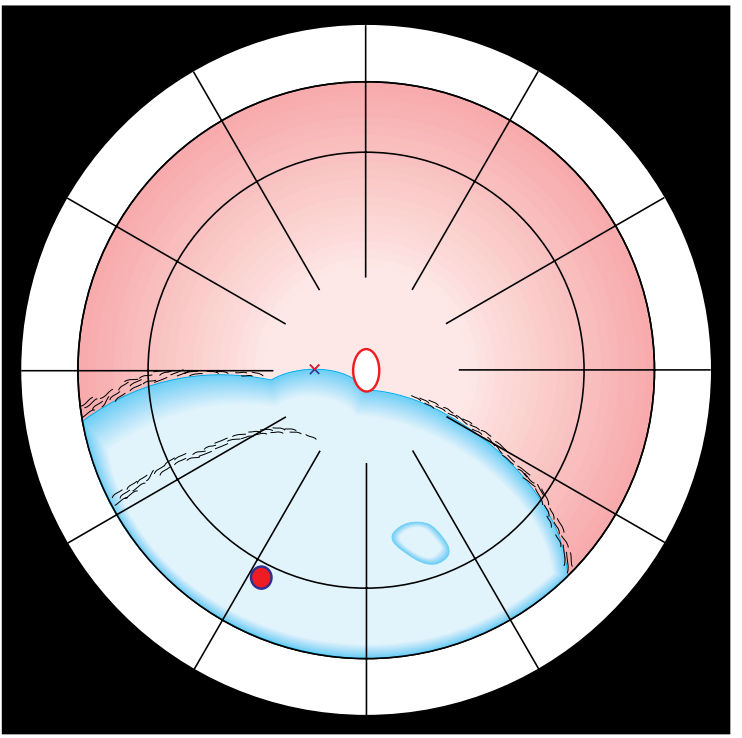


Fig. 8.**11a** An old detachment. There are pigment demarcation lines at the borders of the inferior detachment and beneath detached retina, and the retinal cyst also indicates the prolonged duration of this detachment. The round hole at 7 o'clock is beneath the higher border of the detachment. The detachment came to the patient's attention when it approached the macula.

? Is at least an old detachment an indication to drain, because the fluid is "thick," as some describe it?

▶ No.

Our experience is that old fluid is absorbed as quickly as recent fluid, assuming once again that all of the holes are found and buckled sufficiently. The only factor that might delay the absorption

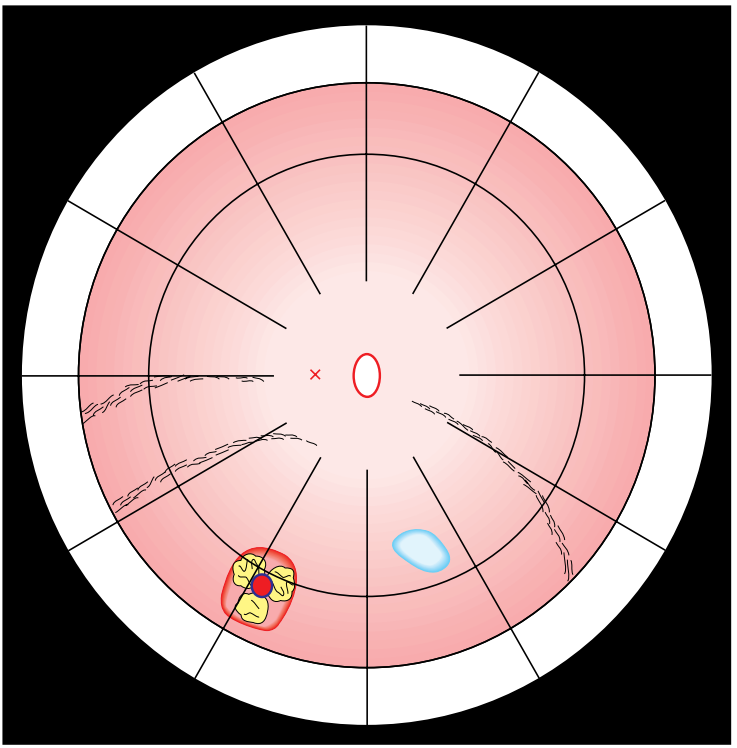


Fig. 8.**11 b** After radial buckling of the hole at 7 o'clock, the retina had reattached without drainage the next day. The cyst and the pigment demarcation lines are visible.

of fluid is not the age either of the detachment or of the patient, but the presence of an "old" choriocapillaris and choroid; a non functioning pigment epithelium.

? How should one proceed with an old detachment?

Since the detachment in Figure 8.**11a** is an extensive one, a search first has to be made in the entire detached area for the presence of breaks. It is an inferior detachment, and the hole at 7 o'clock therefore falls under the 95% Rule of how to find the primary break (see Chapter 2, p. 7).

In this example, the patient did not even realize that he had a long-standing detachment, and had only noticed it recently when subretinal fluid invaded the macula.

As will be recalled, inferior detachments progress slowly. Here again, the break should only be treated using a radial sponge. Due to the small size of the break, a 4 mm sponge without drainage should be selected (Fig. 8.**11 b**). If it were a myopic eye or a very old patient with a very sclerotic choriocapillaris, one might expect delayed absorption of the fluid. However, the macula will be reattached the morning after surgery, and one only needs to wait for a few days until the hole is completely reattached to the buckle. Only then should it be sealed off with laser lesions. As long as there is residual inferior fluid, the patient should be asked to sleep with the head elevated (see Chapter 8.13, p. 212).

8.6.6 Phakia or Pseudophakia

Figure 8.**12 a** once again shows a total detachment, but this time in a pseudophake. Two holes are seen at 11 o'clock and 12 o'clock. In addition, there are what are known as "traction lines" almost over the entire circumference, which in reality represent the insertion of the vitreous base. After a meticulous search with depression of the anterior retina, and especially of the vitreous base, no additional breaks were found.

? What should be done? Should drainage be used, since this is a total and bullous detachment in a pseudophake?

▶ No.

It should be remembered that we still do not want to treat the extent of the detachment, but only the area of the holes. These 2 tears are too close together to be supported by 2 radial sponges. Instead, one should resort to a **short** circumferential 4 mm sponge without drainage (Fig. 8.**12 b**).

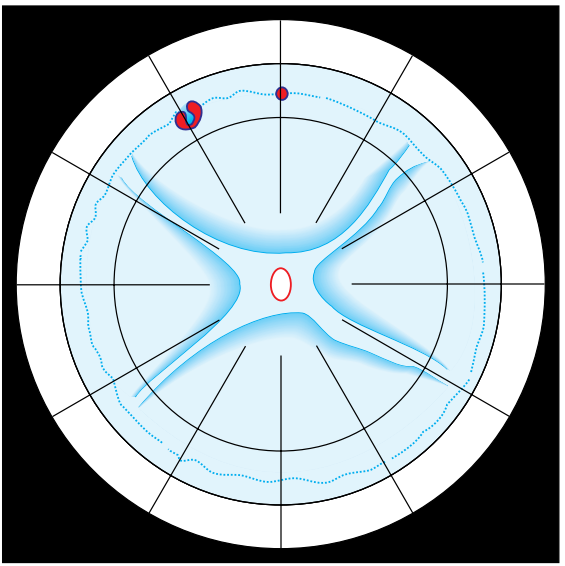


Fig. 8.**12 a** Total detachment in pseudophakic eye. There is a horseshoe tear at 11 o'clock, a round hole at 12 o'clock, and traction lines (insertion of the vitreous base) in the entire periphery.

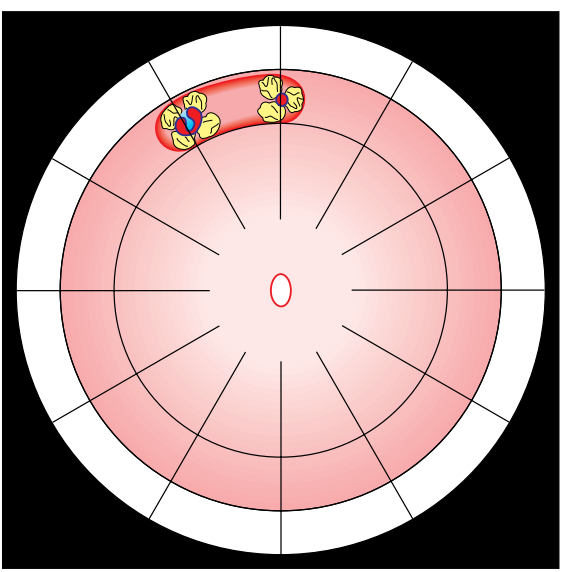


Fig. 8.**12 b** After buckling of the 2 breaks by a **short circumferential** sponge cylinder, the retina had reattached without drainage the next morning. After 1 week, the cryopexy lesions had pigmented. The retina remained attached during the subsequent 15 years.

? Why a short circumferential buckle, and not a more extensive (prophylactic?) one? Why not use a cerclage?

▶ With a short circumferential buckle, there is a smaller probability of producing radial folds converging at the posterior edge of the breaks, causing leakage and thus failure.

A cerclage is not needed, not even as a prospective or prophylactic encirclement, because the entire retina up to the ora has been studied under the biomicroscope preoperatively and visualized with indentation.

● There are therefore no uncertainties in the periphery that need to be walled away using a cerclage.

Admittedly, to be certain that an additional break has not been overlooked, the surgeon and his or her associate will have studied this eye repeatedly if necessary.

? What were the benefits for the patient and for the operated eye?

▶ The retina reattached after 1 minimal extraocular procedure—a mini-buckle without drainage.

The follow-up period with this patient is 15 years, and during that time the retina remained attached, despite the absence of a cerclage.

? Would a primary vitrectomy have been an alternative?

As described below (see Chapter 8.8.5, p. 187), long-term results over a period of 15 years are already available using this minimal extraocular surgery alone. During that time, no secondary cataract or glaucoma developed, and there was no increased risk of the

development of proliferative vitreoretinopathy (PVR), secondary breaks or redetachment. By contrast, comparable long-term results after primary vitrectomy are still lacking, and will not be available for another decade. However, the above-mentioned complications have developed after vitrectomy and that was already after 6–18 months.

8.6.7 Reoperation

? In such a complex eye, why not move on to drainage, cerclage, a gas injection or a primary vitrectomy? Because this time it involves a reoperation, which is more difficult?

▶ No. One should restrain oneself and first consider what the minimal solution might be for solving this complex problem without provoking proliferative vitreoretinopathy by a larger or more invasive approach.

Eyes on which a reoperation has to be performed are frequently congested, and it must be accepted that perforation for drainage carries a greater than average risk of hemorrhage. The most satisfactory method of treatment, and the one with the least morbidity, in this situation is therefore also to find the hole that is leaking and causing failure (see Part 2: Chapter 14. Reoperation of Retinal Detachments without Drainage).

● The tendency to move on to a "larger" procedure just because it is the second operation has little merit, and involves greater disadvantages for the eye to be reoperated on.

● – In addition, the retina will not reattach and remain attached merely because drainage has been carried out.
– It will only reattach and remain attached because the cause of failure has been found, which in 45% is due to another break and in 31% due to an inadequate tamponade, as may be recalled [2].

The chances of succeeding with minimal extraocular surgery are therefore quite good. One should simply search for the break or breaks, or for a break that is leaking, and provide adequate tamponade.

8.6.8 Multiple Breaks

? Are multiple breaks in the detached retina an indication for drainage?

▶ No.

Since a rhegmatogenous detachment is caused by a break or breaks, the task is once again to find all of them and provide adequate tamponade for each. Here as well, drainage of subretinal fluid can be avoided by applying elastic buckles. The presence of more than 1 break, even when they are widely separated, is not an indication for drainage. It should be remembered that multiple breaks close off in rapid succession, and the absorption of fluid follows the same course as if there were only 1 break.

? Are there any indications for drainage at all?

▶ Practically none. We had to search through more than 500 detachments to find 3 in whom we carried out drainage, but only a *partial drainage*.

? Why only partial drainage, after already taking on the risks of drainage, such as perforating the choroid?

▶ To preserve the potential of undrained fluid to use it for testing the quality of reattachment.

- **Partial drainage might be used:**
  - With multiple buckles in the presence of a staphylomatous sclera.
  - In an eye with multiple buckles and decreased outflow or glaucoma.
  - **Since 1987 the injection of an expanding gas is no longer an indication for drainage, because we instead use the balloon–gas procedure** (see Part 2: Chapter 10.5 Balloon–Gas Procedure).

The essential question now is how to provide optimal tamponade for multiple breaks while still using a minimum of sponges.

8.7 Optimal Tamponade for Multiple Breaks

Few detachments will have multiple breaks distributed over the entire circumference of the eye. In general, several holes are located within 1 or 2 quadrants.

- **There will be:**
  1 break or group of breaks within 1 clock hour in **50%** of detachments if a questionable break can be excluded in suspicious areas (otherwise there will be 1 break in only 25% of detachments),
  2 breaks in about **30%**,
  3 breaks or more in about **20%**.

This should be borne in mind during the following discussion of detachments. We shall proceed step by step, selecting the optimal tamponade for the various configurations and distributions of breaks.

8.7.1 2 Breaks Less Than 1 1/2 Clock Hours Apart in a 3-Quadrant Detachment

? In Figure 8.13 a, what would be the smallest and optimal solution as tamponade for these 2 breaks?

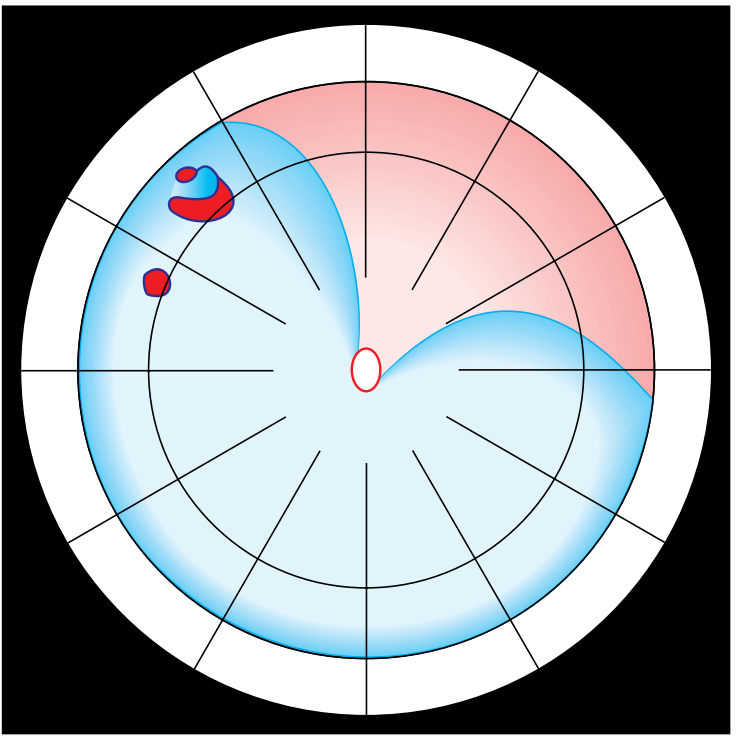


Fig. 8.**13 a** 2 breaks (less than 1 1/2 clock hours apart) in a 3-quadrant detachment. This superior lateral detachment has a horseshoe tear at 10:30 and a round hole at 9:45, both at the same latitude.

First of all, one has to be sure that an additional break in the remaining retinal periphery has not been overlooked, and that the breaks at 9:45 and 10:30 are the only ones. These breaks are too close to each other to be buckled by separate radial sponges. Instead, a 5 mm buckle in circumferential direction should be selected.

- It should be remembered that **the shorter the circumferential buckle, the less** the chance that retinal folds will cause posterior leakage from the break.

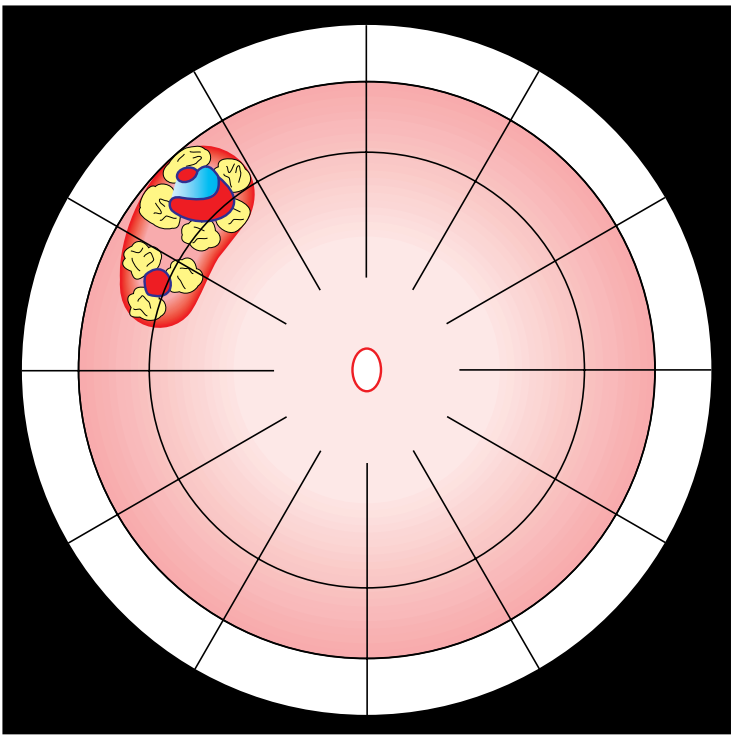


Fig. 8.**13 b** A **short circumferential buckle** (5 mm) from 9:30 to 11 o'clock was sewn onto the sclera without drainage. The retina reattached. The cryopexy lesions, applied intraoperatively, have pigmented after 1 week; the horseshoe tear is sufficiently sealed off toward the ora, and also adequately tamponaded (anteriorly and posteriorly) by the circumferential buckle—since otherwise the retina would not have reattached without drainage.

The buckle will have an extension of $1^1/_2$ or a maximum of 2 clock hours, and drainage should not be used. This will be sufficient for the retina to reattach—and as Figure 8.**13 b** shows, it did.

8.7.2 3 Breaks in a 3-Quadrant Detachment

In contrast to the previous detachment, the 3 breaks in Figure 8.**14 a** are more than $1^1/_2$ clock hours apart from each other. This means

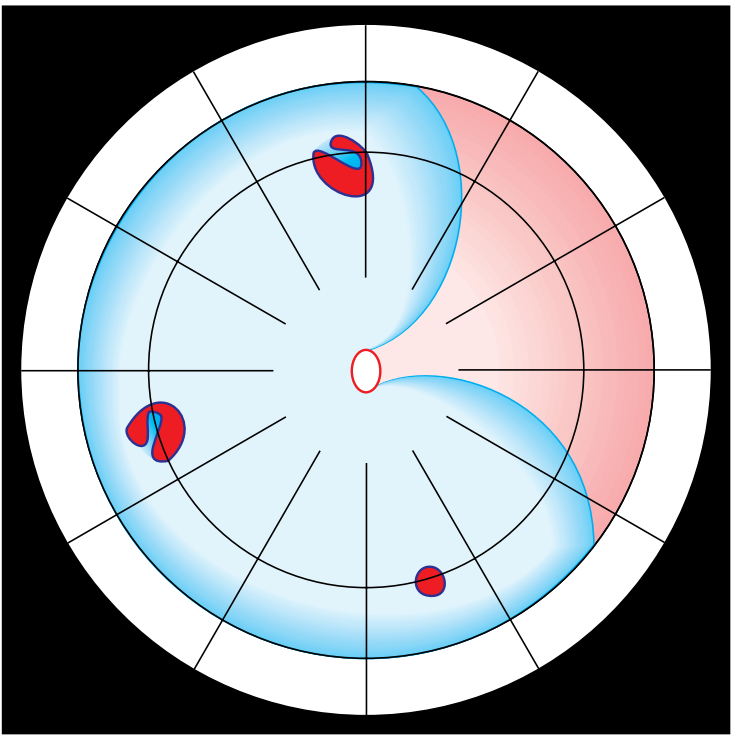


Fig. 8.**14 a** 3 breaks in a 3-quadrant detachment. The 3 breaks are 2 1/2 to 3 clock hours apart.

that this time, each of the breaks can be supported by a radial sponge without drainage (Fig. 8.**14 b**).

? Why not use a cerclage instead?

▶ But why apply a cerclage in an area of attached retina (with an extension of 3 1/2 clock hours), as well as in an area of detached retina without a break.

? A cerclage as a "prophylactic" or "prospective" measure?

▶ No.

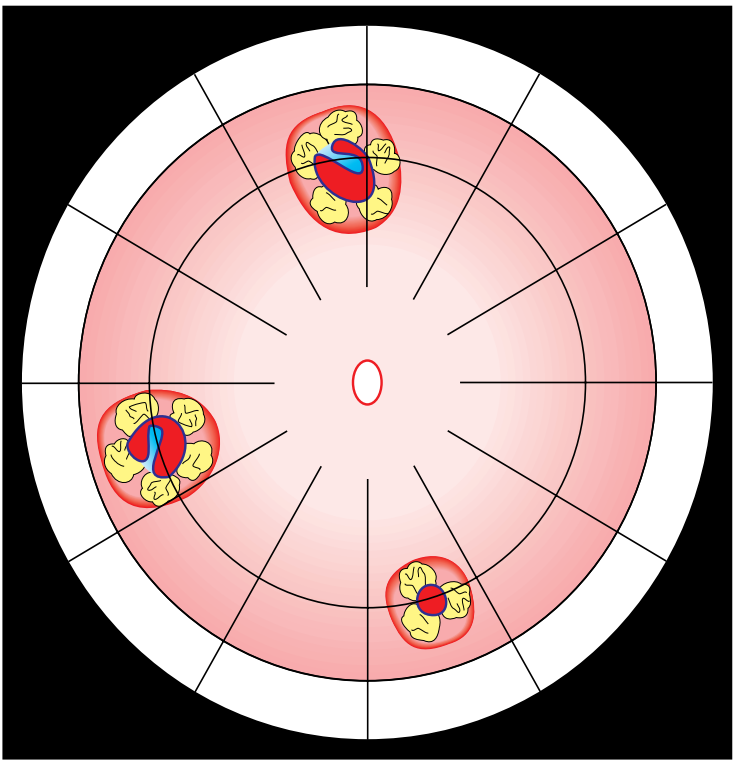


Fig. 8.**14 b** The 3 breaks were tamponaded by 3 radial sponge cylinders without drainage. Cryopexy was applied intraoperatively, and the retina reattached. Special care was taken to seal off sufficiently the operculum of the 2 horseshoe tears, where future vitreous traction might be exerted. The retina remained attached during a 14-year follow-up period.

In this situation, the minimal extraocular approach would consist of an individual radial tamponade for every break, which at the same time represents an optimal tamponade for the horseshoe tears, with optimal long-term results [3].

8.7.3 Multiple Breaks in a 1 1/2-Quadrant Detachment

The detachment with multiple breaks in Figure 8.**15 a** is certainly not an indication for using a cerclage—all the more so since 2 1/2

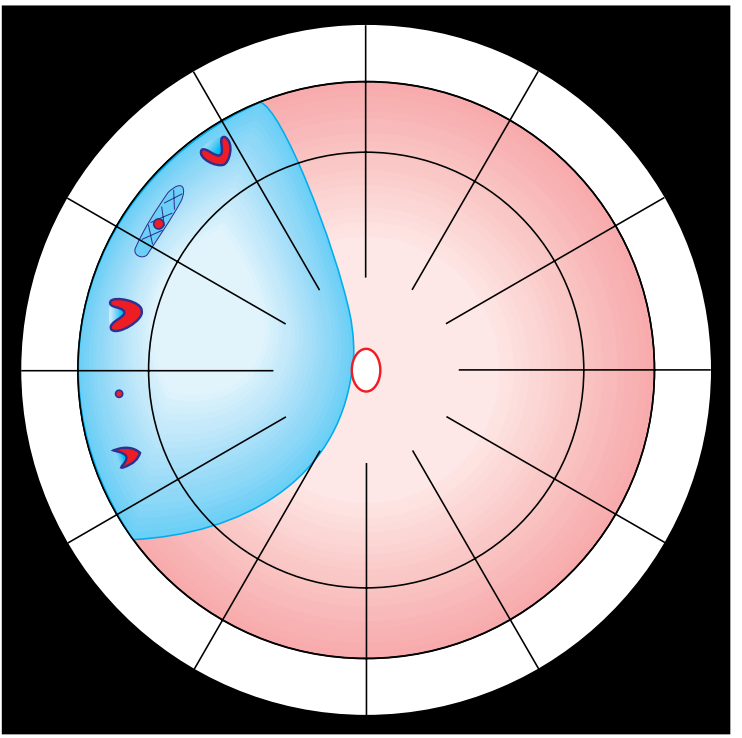


Fig. 8.**15 a** Multiple breaks in a 1 1/2-quadrant detachment. In this detachment, there are 3 horseshoe tears and a round hole at the same latitude. The "round hole" in lattice degeneration at 10 o'clock is a pseudohole. In lattice degeneration, holes within lattice are in general pseudoholes, and any real holes, if at all, are at the edges of lattice.

quadrants are still attached and without obvious retinal pathology. If there were additional breaks in the attached retina, they would of course be treated using laser or cryopexy.

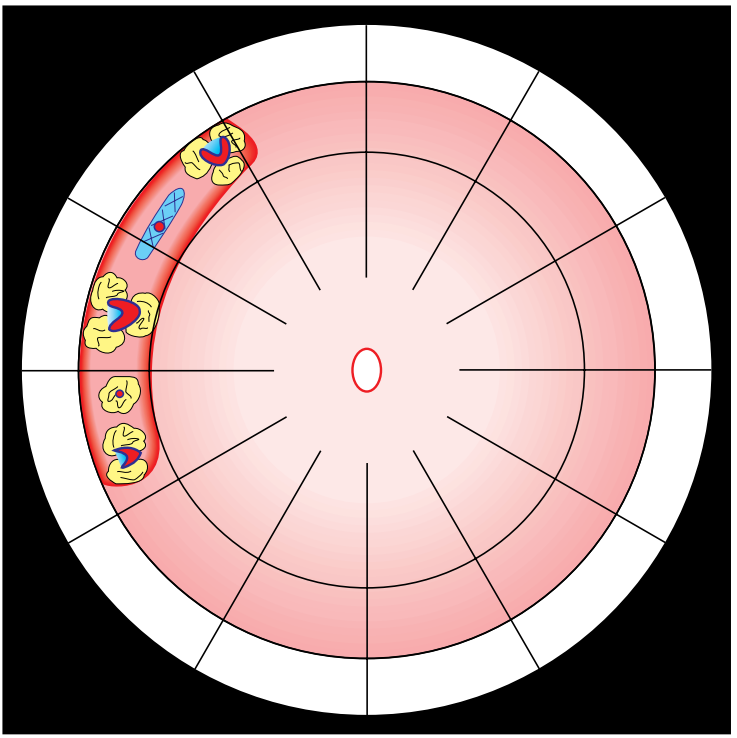


Fig. 8.**15 b** After the breaks had been tamponaded with a **short circumferential buckle** (4 mm in diameter), with precise localization of each break, the retina reattached without drainage. Pigmentation around the breaks was completed after 1 week (notice that the lattice degeneration was not treated with coagulation). Since the buckle crosses a rectus muscle, the patient has to exercise ocular motility repeatedly starting day 1 postoperatively, in order to counteract postoperative diplopia.

? What should one do in this limited 1 1/2-quadrant detachment, with multiple breaks?

▶ It is not possible to use several radial buckles—instead, a circumferential sponge of 4 mm in diameter can be selected by the expert, or, for those less experienced, a 5 mm sponge fixed with 2 or 3 mattress sutures and without drainage (Fig. 8.**15 b**).

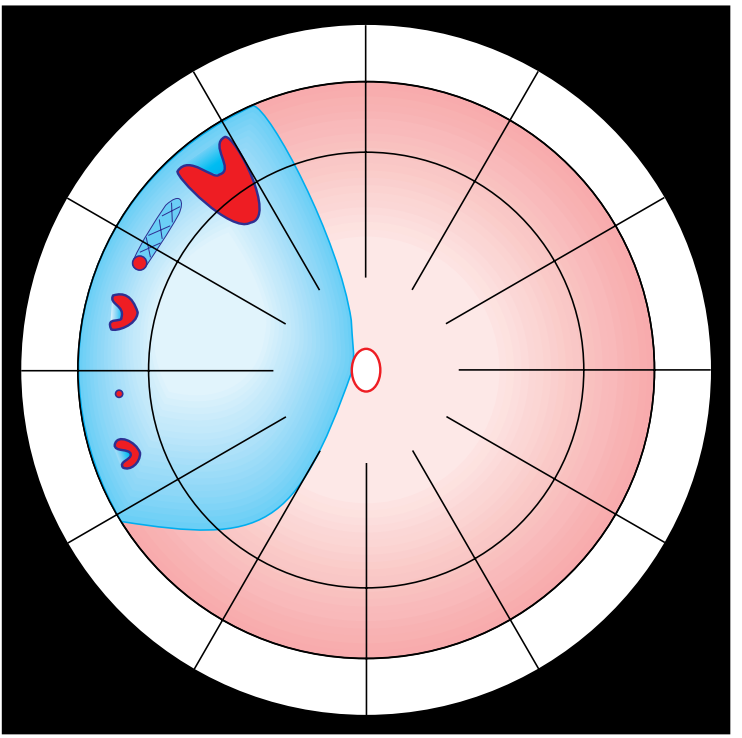


Fig. 8.**16 a** Multiple breaks of various sizes in a 1 1/2-quadrant detachment. The breaks from 8:15 to 9:30 are at the same latitude, and the "hole" within the lattice is a pseudohole. However, the horseshoe tear at 10:45 extends more posteriorly than the other breaks.

However, any stretching of the circumferential sponge should be avoided, because we do not want to increase the risk of radial folds. One again, the retinal artery has to be checked for patency.

8.7.4 Multiple Breaks of Various Sizes in a 1 1/2-Quadrant Detachment

? In the detachment shown in Figure 8.16 a, is a circumferential buckle still a good solution?

▶ No; but first analyze the characteristics of the breaks.

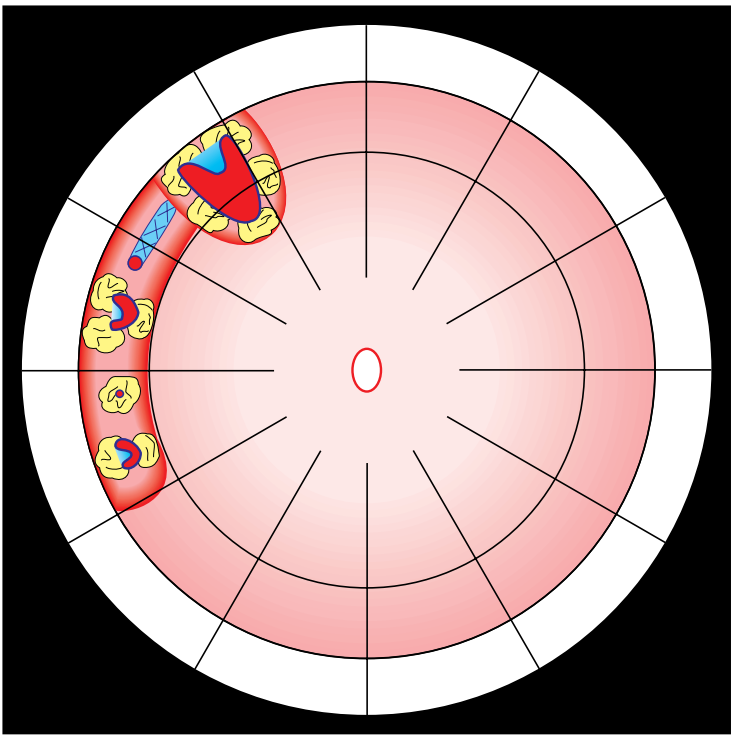


Fig. 8.**16 b** The breaks at the same latitude were supported by a circumferential 4 mm sponge cylinder, and the horseshoe tear at 10:45 was supported by a radial 5 mm sponge without drainage. The retina reattached, and the cryopexy lesions had pigmented after 1 week. Note that the lattice with the pseudohole was not coagulated. Postoperatively binocular exercises by the patient (to ensure ocular motility) are mandatory to prevent postoperative diplopia.

It should be remembered that it is not an optimal treatment to buckle a horseshoe tear as large as the one at 10:45 using a circumferential sponge.

? Why not? Or what would be the risk if you combined radial and circumferential sponges instead?

▶ Think about it and analyze the problem.

The lattice between 9:45 and 10:30 contains a round hole, but it lies within the lattice degeneration. What does this imply?

- **Round holes within lattice degeneration are in general only lamellar holes.**
  Tears at the edges of lattice are full-thickness tears.

Knowing that there is no hole between 9:45 and 10:30, we can go ahead and buckle the horseshoe tear at 10:45 using a radial 5 mm sponge, and risk positioning the lattice on the adjoining circumferential buckle from 8 o'clock over 9 o'clock to 10:30 (Fig. 8.**16 b**).

- It should be borne in mind, however, that the area in which the **radial and circumferential buckle connect with each other does not provide a useful tamponade**. In this area, therefore, one ***can never position a break*** to be tamponaded.

If there is a hole in this connection between the radial and circumferential buckle, another buckling configuration should be selected.

? Which option would you choose?

If there is another hole at 10:15 instead of lattice, then the radial buckle at 10:45 should be enlarged toward 10 o'clock, so that this hole will also be supported by the radial buckle.

- **When a radial and circumferential buckle are being combined, one should always make sure that the connection of the 2 buckles is positioned in an area in which *a hole is definitely not present*.**

? Why?

▶ Because otherwise the buckling is doomed to fail due to leakage from this very hole.

However, in spite of these multiple breaks, there is still no indication to extend the buckling to a cerclage or to proceed to a primary vitrectomy, which at present still harbors the risk of cataract, anterior proliferative vitreoretinopathy, new breaks, or glaucoma [4–7].

8.7.5 1 Break in a 3-Quadrant Detachment with Moderate Proliferative Vitreoretinopathy

Figure 8.**17 a** shows a detachment with starfolds in 1 quadrant. Analyze the contours carefully; they are convex in spite of the proliferative vitreoretinopathy. This means we are still confronted with a rhegmatogenous detachment. The starfolds are not too posteriorly located, and are definitely $1^1/_2$ clock hours away from the break to be buckled.

? Is this an indication for a primary vitrectomy with membrane peeling and an internal tamponade? Or a cerclage?

▶ At the first attempt, certainly not.

Now let us return to the surgical problem. We have confirmed that the situation is a rhegmatogenous detachment with convex borders—i.e., the break at 1:30 has to be tamponaded. Therefore:

? Why not try buckling this break first?

▶ Support the hole at 1:30 using a radial sponge with cryopexy (Fig. 8.**17 b**).

? Will you carry out drainage?

▶ No.

? Why not?

▶ An eye with proliferative vitreoretinopathy (PVR) at this stage is in a vulnerable condition, i.e., in limbo, and can easily progress to a more severe stage of PVR.

We know that a breakdown of the blood aqueous barrier will provoke or induce progression of PVR.

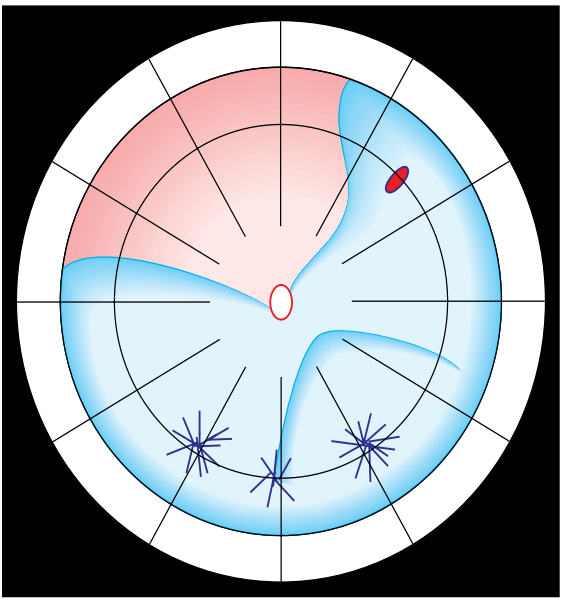


Fig. 8.**17 a** 1 break in a 3-quadrant PVR detachment of moderate degree, the starfolds are in 1 quadrant. Hole at 1:30 is positioned within 1 1/2 clock hours beneath the superior border of the detachment (cf. Rule 1, p. 14). The borders of the detachment are convex; it is a rhegmatogenous detachment.

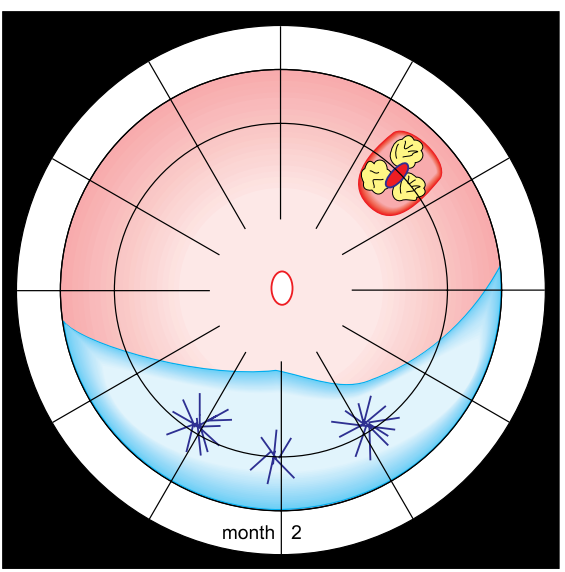


Fig. 8.**17 b** After radial buckling of the hole at 1:30, the retina reattached except inferiorly; the macula is reattached. There is a residual tractional detachment, which extends to the ora and has concave contours and concave surfaces; still present 2 months postoperatively (due to traction of the starfolds).

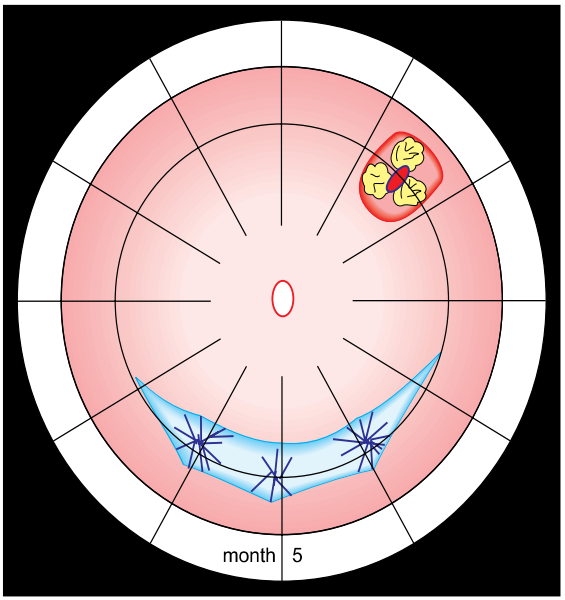


Fig. 8.**17 c** After 5 months with full mobilization of the patient, the tractional detachment has further decreased, and is only seen in the area of the starfolds; the anterior retina has reattached.

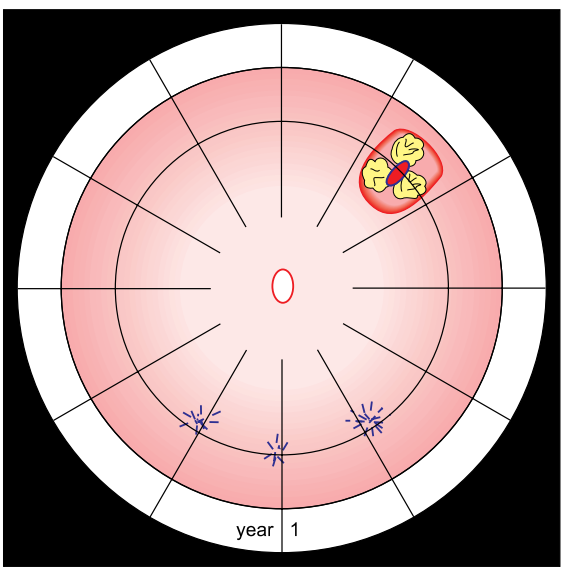


Fig. 8.**17 d** After 1 year, the starfolds are hardly visible any more. The retina remained attached during a follow-up period of 16 years.

- This is the reason why we do not consider entering the eye surgically, but instead carry out an extraocular operation limited to the area of the break, without drainage.
  In addition, this eye should be handled carefully during surgery, avoiding too much indentation with the cryoprobe or excessively heavy cryopexy of the break.

The residual inferior detachment is not a failure.

? **How can we be certain that this residual detachment in a PVR detachment is not a failure?**

▶ First, analyze its contours; this time they are **concave**.

? **What does this imply?**

▶ It is a ***residual tractional detachment*** (see Chapter 8.13, p. 212).

Even though the patient is mobilized, over time the detachment regresses to a smaller inferior anterior tractional detachment limited to the area of the starfolds: At 5 months (Fig. 8.**17 c**) the retina is reattached, and after 1 year the starfolds are hardly visible (Fig. 8.**17 d**).

- In fact, we can conclude that buckling a break in a PVR detachment offers a test for the degree of PVR present. A resultant reattachment suggests a more favorable course—but
  it also implies that this extraocular minimal operation did not induce progression of PVR, and instead did not interfere with its regression over time.

If this minimal approach is not successful, one can of course move on to intraocular surgery with membrane peeling.

8.7.6 Group of Breaks in a 3-Quadrant Detachment with Moderate Proliferative Vitreoretinopathy

Figure 8.**18 a** shows a PVR detachment with starfolds in 2 quadrants and a group of several breaks. The problem here is slightly more complex.

? Will you move on to a primary vitrectomy with an intraocular tamponade or to a cerclage this time?

▶ No; instead, first try segmental buckling of the group of breaks without drainage.

Of course, the entire extent of the 3-quadrant detachment has to be searched for additional breaks. The retina has been indented and visualized up to the ora. The patient has been studied several times both by yourself and even by your associate. There is definitely only this group of breaks at 1:30. Since additional breaks have not been found, this group of breaks is buckled using a 7 mm radial sponge, without drainage.

? Why not support the starfolds by an additional circumferential buckle or a prospective cerclage?

▶ This is because starfolds will either progress, in which situation one should move on to a vitrectomy, or—especially, if the eye was not traumatized too much by the surgery—they will regress over time.

As is seen from the follow-up, this is what in fact happened. The inferior residual tractional detachment regressed over a period of 2 months (Fig. 8.**18 b**), and after 1 year only dry starfolds were visible.

The operation described above was carried out using local anesthesia. Applying extraocular minimal surgery, there was no risk of the patient subsequently developing a secondary cataract, anterior vitreoretinal proliferation, glaucoma, or other complications accompanying a primary vitrectomy [4–7]. Not applying a cerclage also means that the circulation of the retina and choroid is not jeopardized, as reported in recent publications after a cerclage

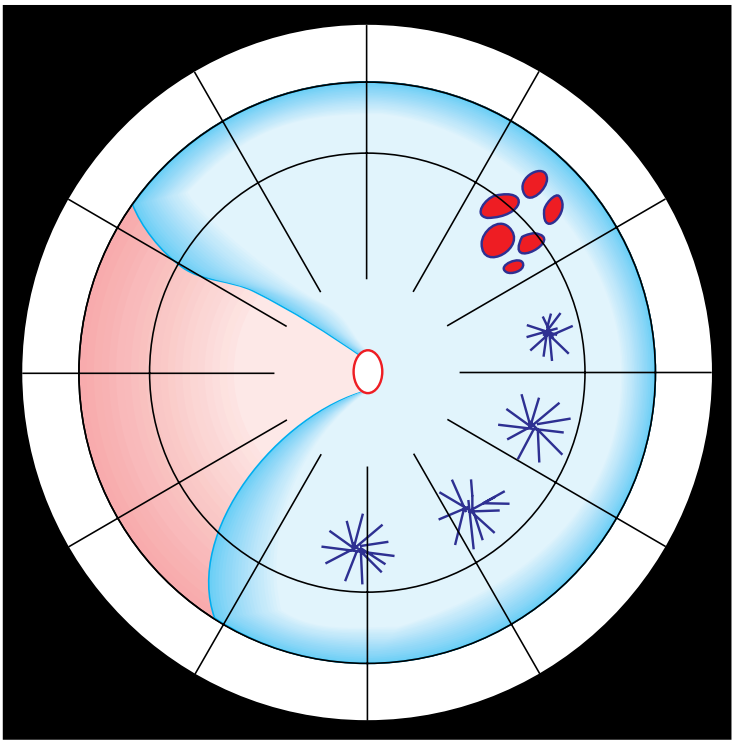


Fig. 8.**18 a** A group of breaks in a 3-quadrant PVR detachment of moderate degree. The breaks are between 1 o'clock and 2 o'clock, with adjoining starfolds from 2:30 to 6 o'clock posterior to the equator. No additional hole was found between 10 o'clock over 12 to 1 o'clock.

[8–13]. In addition, when using minimal extraocular surgery regained visual function will not deteriorate during the long-term follow-up in comparison to the fellow eye [3].

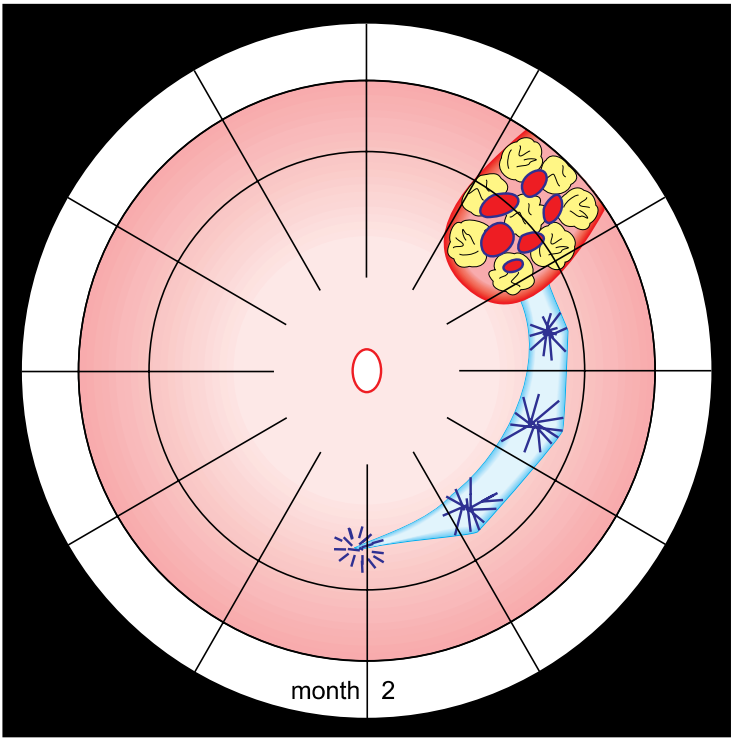


Fig. 8.**18 b** After the breaks had been buckled with a 7 mm radial sponge cylinder without drainage, the retina and macula reattached, except for a residual tractional detachment located at the starfolds, which was still present 2 months postoperatively; it disappeared over time. The retina remained attached during a follow-up period of 17 years.

8.8 Tamponade for Large Tears or Multiple Breaks (at Different Latitudes) over 40°–70° in Circumferential Arc

8.8.1 Introduction

Only a few retinal detachments are caused by a large retinal tear or multiple tears (at different latitudes) extending more than 40°–70° in circumferential arc. They are the exception, with a frequency ranging between 1% and 2%.

If a tear is larger than 40°, it exceeds the limits of radial buckling with sponge cylinders, because 2 of the largest sponges, 7.5 mm ovals, will close only a 40° tear.

? More than 2 sponges sutured side by side are not feasible. Why?

▶ Because the span of the mattress suture is too long to provide adequate compression.

Buckling with a circumferential explant or a cerclage will result in radial folds known as "fishmouthing," causing posterior leakage from the tear. The same is true for constellations of retinal tears that together span a circumference of more than 40°–70°.

? Why is a combination of a radial and circumferential sponge not suitable as a tamponade?

▶
- Because one of the breaks will be positioned at the junction of the buckles, so that it will not be sufficiently tamponaded, resulting in leakage.
- Consequently, a constellation of multiple breaks at different latitudes with a circumferential arc of more than 40°–70° that are too closely spaced for separate buckles should be treated as a single large tear.

An alternative treatment would be an internal tamponade using an expanding gas, but the gas technique fails to counteract substantial traction, if present, beyond the duration of the bubble in the eye, and will therefore involve a significant rate of redetachment (see Part 2: Chapter 10. Temporary Gas Tamponade without Drainage).

Another alternative would be a primary vitrectomy—an elegant technique, but one that at present is still associated with serious complications. Early complications are already apparent, and the long-term results are still pending [5, 6].

A further alternative, and one that even represents an extraocular approach, would be a scleral pouch.

8.8.2 Scleral Pouch

It was first described by Paufique in 1965 [14], using donor sclera and fascia lata as filling.

? Which problems with the original pouch operation had to be overcome?

- Drainage of subretinal fluid was necessary.
- The pouch of donor sclera, when filled, increased in size toward the conjunctiva, resulting in a large external buckle known as a "rucksack," but not providing deep indentation of the globe.
- Using the nontransparent donor sclera, it was difficult to cut a pouch that was large enough, but not too small, to cover the localizing scleral marks.
- In addition, even distribution of fascia lata or silicone pellets (which we began to use) within the pouch was not possible, due to lack of visual control.
- As a result, the indentation at the fundus appeared uneven, and therefore did not provide optimal tamponade.

To circumvent these problems, in 1978 instead a Dacron-reinforced silicone sheeting as pouch material was developed by Lincoff and Kreissig [15]. The elastic sheeting is 0.5 mm thick, and the Dacron mesh has a tricot twist to preserve its elasticity. The mesh is completely embedded in the silicone sheeting, so that the surfaces are smooth. Importantly, the sheeting is relatively transparent in spite of the mesh, so that even distribution of the stuffing can be monitored. This new silicone pouch is stuffed with silicone pellets, obtained by dicing a cylinder of silicone sponge into cubes of 2 mm on each side (Fig. 8.**19**).

8.8.3 Clinical Study

The study described here was intended to answer the following question:

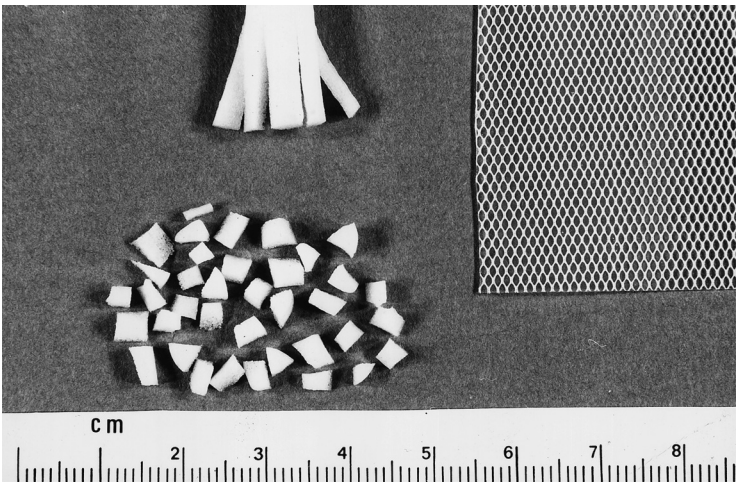


Fig. 8.**19** Materials for the silicone pouch. *Left:* silicone sponge pellets cut from a 7.5 mm sponge cylinder. *Right:* Dacron-reinforced silicone sheeting; it is transparent in spite of the Dacron mesh, which is completely embedded in the silicone sheet so that the surfaces are smooth.

? How often is a pouch operation likely to be indicated in a series of consecutive detachments?

▶ The indication is extremely rare, ranging at around 1%.

In 2 000 consecutive detachments (1 000 treated by Prof. Lincoff in New York and 1 000 by our group [16]) the indication for a pouch was given in 20 eyes (1%).

● **The indications for the pouch operation are as follows:**

- The retinal tear subtends a circumferential arc of more than 40°–70° (Fig. 8.**20**).
- There are 2 or more large horseshoe tears closely spaced, which together span more than 40°–70° in circumferential arc (Fig. 8.**21**).
- There are multiple tears, large and small, closely spaced, but at different latitudes, which together have a circumferential arc of more than 40°–70° (Fig. 8.**22**).

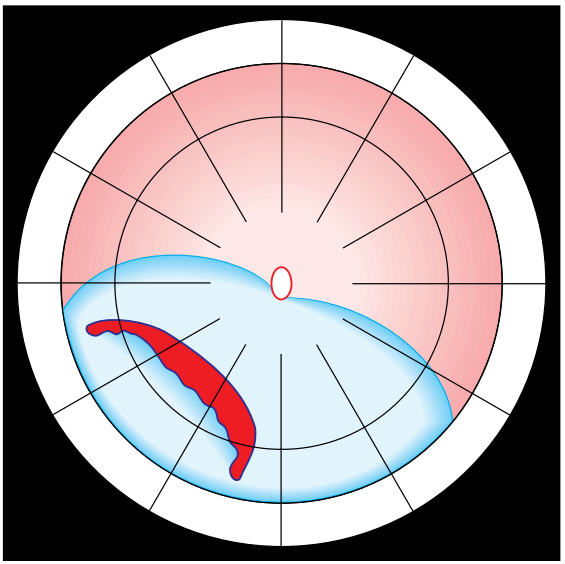


Fig. 8.**20** An inferior retinal detachment caused by a large tear, with a circumferential arc of approximately 70°.

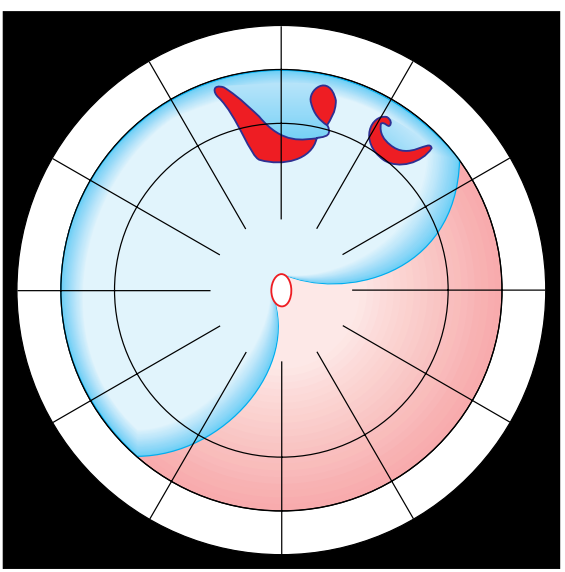


Fig. 8.**21** A retinal detachment caused by 2 horseshoe tears too closely spaced for separate radial buckles, and whose combined circumferential arc spans almost 70°.

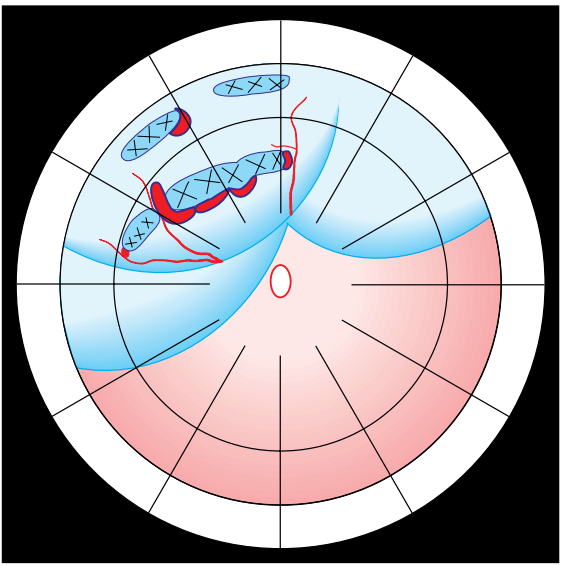


Fig. 8.**22** A retinal detachment caused by multiple tears at different latitudes, which together have a circumferential arc of about 65°. The small red spot at 9:15 (lateral edge of lattice degeneration) was considered to be a hemorrhage.

For tears larger than 70° (7 of the 2000 detachments), the pouch operation did not prove to be a useful treatment; further details are given below (see Part 2: Chapter 10.6 Application of Expanding Gases).

8.8.4 Technique

The edges of the tears are treated with cryopexy under ophthalmoscopic control. For a large tear, 3 applications that localize the anterior horns and the posterior center of the tear are marked on the sclera with gentianviolet. For a constellation of tears, the anterior and posterior extremes of the tears are localized and marked on sclera. In this situation, the group is then regarded as a single large tear. A portion of silicone sheeting is placed over the tear or tears marked on the sclera, and a patch is cut that is at least 2 mm larger than the tear or tears in every dimension (Fig. 8.**23**). In tears that have a larger circumferential dimension than radial one, the patch is modeled with an anterior–posterior direction that is at least $^{2}/_{3}$ as long as in the circumference.

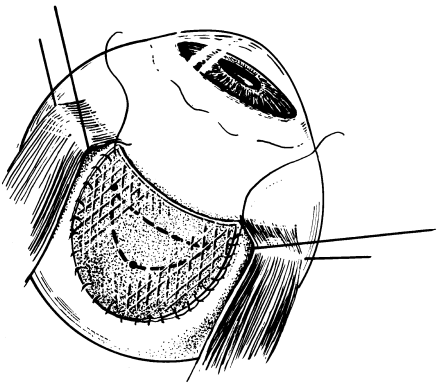


Fig. 8.**23** Silicone sheeting in place over localizing marks for the large tear shown in Fig. 8.**20.** A pouch with radial dimension overlaps the localizing marks by at least 2 mm, and is sutured onto the sclera with a running suture. The anterior border is left open for filling.

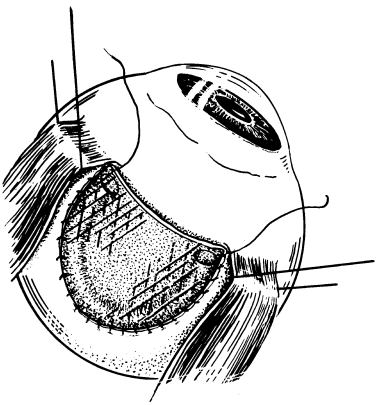


Fig. 8.**24** The rim of the pouch is lined with a 3 mm silicone sponge, providing an even elevation at the border of the radial pouch buckle and preventing slippage of pellets through the suture line.

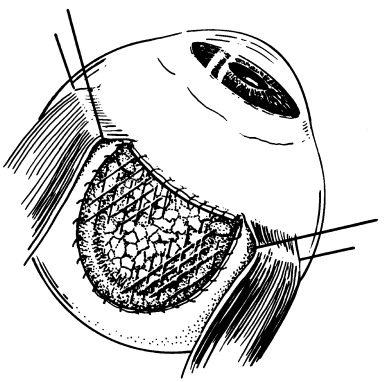


Fig. 8.**25** The pouch is filled with silicone pellets. An even filling is monitored through the transparent sheeting. The anterior rim of the pouch is closed with a running suture. The sharp lateral edges of the pouch are rounded off in order to prevent later dissection through the closed Tenon's capsule and conjunctiva.

? Why?

▶ In order to retain the advantages of radial buckling with the pouch operation.

Three sides of the patch are then attached tightly to the sclera using a running suture, and the anterior border is left open for filling. When using silicone pellets for filling, a 3 mm silicone sponge cylinder is used to line the rim of the pouch (Fig. 8.**24**). This has the effect of providing even elevation at the borders of the buckle, and it prevents migration of sponge pellets through the suture line. The remainder of the pouch is then filled with silicone pellets. Even distribution of the pellets is facilitated by the transparency of the silicone sheeting. Before the suture is finally tied, the contents of the pouch are irrigated with 40 mg/ml of gentamicin sulfate solution administered through a blunt 18-gauge needle that is inserted among the pellets.

● **One should be aware of the danger of overfilling the pouch.**
Since filling elevates intraocular pressure, the central artery has to be monitored periodically for patency, particularly when the suture that closes the anterior border of the pouch nears completion (Fig. 8.**25**).

Closure of Tenon's capsule and conjunctiva is carried out in the same way as described for segmental buckling. Additional precautions have to be taken in order to cover the entire anterior borders of the silicone sheeting sufficiently. It should be made certain that the 2 lateral anterior edges of the silicone sheeting, do not have sharp edges (cut round edges!) to avoid subsequent dissection through the conjunctiva.

Drainage of subretinal fluid is not performed with this procedure, and at the end of the operation one should therefore check the central artery for pulsation once again. Some hours later, intraocular pressure will return to normal levels, resulting in a deeper indentation into the globe. If the localization was made precisely, all of the breaks will be tamponaded and the retina will reattach (Fig. 8.**26**).

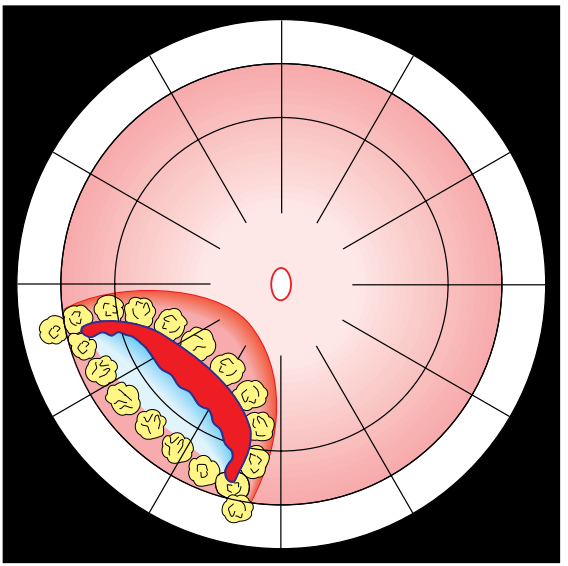


Fig. 8.**26** The large tear of the retinal detachment in Fig. 8.**20** was tamponaded using a radial pouch measuring $^{2}/_{3}$ of the circumferential extent of the tear. The retina reattached without drainage of subretinal fluid. The tear is surrounded with cryopexy lesions applied during surgery. If necessary, additional laser applications can be placed after reattachment. If the pouch should be removed a few weeks after reattachment (e.g., to eliminate the bulge under conjunctiva), the retinal findings have to be stable, and it must be ensured that the tear is sufficiently secured by scars.

8.8.5 Results

Of the 20 tears or constellations of tears (at different latitudes) that were greater than 40°–70° in circumferential arc, 19 were reattached and remained attached during a 6-year follow-up period, with no secondary deterioration of visual function.

? Another question that might arise: Is there with the availability today of vitrectomy [17] and expanding gases [18, 19], still an indication for the pouch operation?

▶ Due to the 2 procedures mentioned (which involve intraocular surgery), there are fewer indications for the extraocular pouch operation, but it does still have a place **for selected detachments.**

● **The indication for a pouch operation might be given:**
- If an expanding gas cannot be used because the large tear or the constellation of tears is located inferiorly
- If there is substantial vitreous traction, and one wishes to avoid a primary vitrectomy in presence of a clear lens.

This is because, at present, vitrectomy is still associated with serious complications (cataract, PVR, or secondary breaks)—in contrast to the pouch operation, which can therefore still be the one of choice. This is all the more relevant in young patients, as favorable long-term results are already available for the extraocular pouch operation, i.e., there will be no late deterioration of visual function due to secondary complications.

● An indication for a pouch operation may therefore be present if the large tear or group of tears are located inferiorly (Fig. 8.**26**), or if one wishes to select, for a young patient, a procedure with known long-term results, which are favorable for the pouch operation.

Or if the difficult tear or tears are located superiorly and an expanding gas operation seems not feasible (glaucoma, no compliance of patient) one could also consider a pouch operation.

? Why?

▶ Because this procedure is extraocular. However, this statement might be qualified by adding that one can always try **to use the pouch only as a temporary buckle,** i.e., one can remove it by all means after a few weeks—of course, only on the premise that the tears are sufficiently sealed off with scars, and that the retinal findings have stabilized.

- **In this situation, the pouch operation would mean only a temporary large buckle for the eye, comparable to the effect of a balloon buckle** (see Part 2: Chapter 9. Temporary Balloon Buckle without Drainage).

8.8.6 Summary

The episcleral pouch technique, by using elastic materials, provides a means of extending radial buckling without drainage to retinal tears or constellations of tears (at different latitudes) with a circumferential arc of more than 40°–70°. However, the radial design of the pouch reaches its practical limits when the circumferential dimension of the tear or tears to be buckled exceeds 70°—i.e., 14 mm at the equator.

- **Advantages of the elastic radial pouch are:**
  - It makes extraocular treatment of these difficult retinal detachments feasible
  - It does not require drainage of subretinal fluid
  - It can be applied to relatively posterior tears (it even can be removed after reattachment)
  - It is effective for large inferior tears, since one of the alternatives—the expanding-gas operation—cannot provide optimum tamponade in these patients. The other alternative, an intraocular approach with vitrectomy and gases, liquid perfluorocarbons or silicone oil, is still associated with greater morbidity at present
  - For selected detachments it represents a favorable alternative to intraocular surgery
  - It is possible to apply the extraocular pouch as a temporary buckle, removing it after retinal reattachment. However, one must be certain that the retinal findings have stabilized and that the tears are sufficiently surrounded by cryopexy or laser lesions.

However, the pouch operation is time-consuming, but (and this is all that counts) it works. Above, all:

1. It allows nondrainage of subretinal fluid.
2. It has a reattachment rate of 95%, as good as that of the sponge operation.
3. Last but not least, it provides favorable long-term results in relation to visual function.

8.9 Tears over 70° in Circumferential Arc

Tears larger than 70° are fortunately infrequent. In a series of 2 000 consecutive detachments, they occurred in 0.4%. These large horseshoe tears are actually known as "giant tears." They are difficult to correct with external buckling, and if this is intended, they can only be buckled circumferentially.

? Why only circumferentially?

- Because the posterior edge of a radial pouch extending more than 70° in circumference would intrude on the posterior pole.
- Instead, a circumferential buckle would have to be selected; **however,** as one might expect, this would be **prone to fishmouthing, resulting in failure** [20] (Fig. 8.**27**).

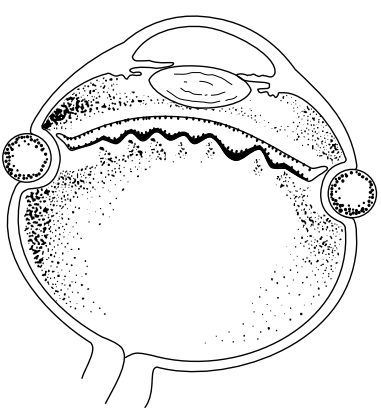


Fig. 8.**27** The retina of a giant tear (150°) is seen here under compression using a circumferential buckle. The posterior edge of the tear is compressed, resulting in several radial folds and a large fold causing fishmouthing, with subsequent leakage.

- **The limits of external buckling are therefore reached with tears of more than 70°:**
  - **Instead,** an internal approach has to be selected as treatment—i.e., **an internal tamponade** either using gas or silicone oil, with or without vitrectomy (for further details on the treatment of giant tears, **see Part 2: Chapter 10.6 Application of Expanding Gases).**

8.10 Tamponade of Oral Disinsertions (Retinal Dialyses)

Oral disinsertions are large retinal tears, which occur in less than 4% of detachments (Fig. 8.**28**).

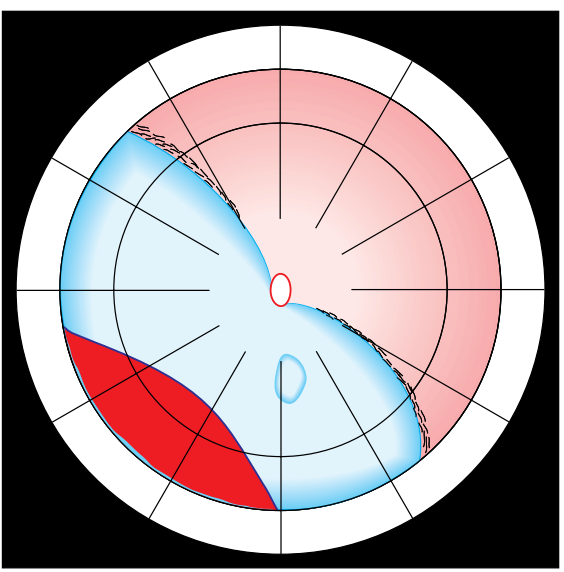


Fig. 8.**28** An old retinal detachment caused by an oral disinsertion of less than 90°. The posterior edge of the tear has the same length as the anterior edge, there is **no additional tearing in radial direction**. Pigment demarcation lines and an intraretinal cyst are evidence that it has persisted for a long period.

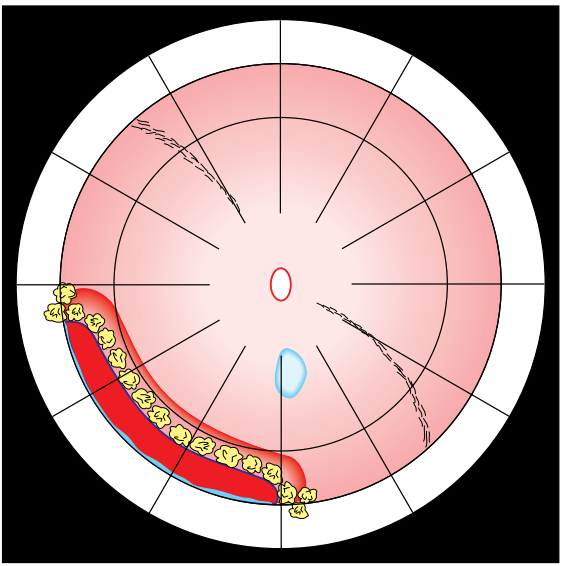


Fig. 8.**29** The oral disinsertion was buckled with a 5 mm circumferential sponge, without drainage of subretinal fluid. The retina reattached the next morning, despite the long duration of the detachment.

? What is the difference between an oral disinsertion and a giant tear, which have comparable circumferential dimensions?

▶ An oral disinsertion is ***not a horseshoe tear.***

This means that the posterior edge of an oral disinsertion, in contrast to a horseshoe tear, is not larger than the anterior circumference. This is the reason why an oral disinsertion of up to 90° can still be treated using a circumferential buckle. In this type of detachment, reattachment can still take place without posterior retinal redundancy, i. e., without fishmouthing (Fig. 8.**29**). Now the question is:

? What is the rate of reattachment of oral disinsertions when circumferential buckling is used as treatment? Are not failures to be expected, simply because of the use of a circumferential buckle?

▶ The answer, perhaps unexpectedly, is: **No.**

As reported by Nadel et al [21], the reattachment rate is in a range reaching 100%. (One might speculate that in order to achieve a surgical success rate of 100%, one would simply have to concentrate on treating only oral disinsertions. However, this is unfortunately not possible, since you would have to wait several years to obtain a substantial number of these selected detachments, with their frequency being less than 4%.)

? Where exactly should the circumferential buckle be placed for treatment?

The cryoprobe must first of all be used to localize the 2 lateral borders of the oral disinsertion. This is easy, as there is no parallax. An additional freeze is then applied on either side within untorn retina, and also in the pars plana here. This is to counteract future additional tearing. The entire posterior circumference of the oral disinsertion is then treated with transscleral cryopexy, under ophthalmoscopic monitoring. The most posterior lesion is marked on the sclera. Additional marks are placed with gentianviolet on the line toward the ora.

● To each of these localizing marks, *2 mm are added posteriorly,* and the circumferential mattress sutures are centered around these more posteriorly positioned marks.

An oral disinsertion extending for $1^1/_2$ clock hours can be treated with a 4 mm sponge (if the buckle is correctly centered), but in one of *more than $1^1/_2$–3 clock hours* (90° in extent)—especially when there is a great deal of dislocation of the edge in posterior direction—the tear should be buckled with a *5 mm full-thickness sponge cylinder,* again without drainage of course (Fig. 8.**29**).

? Particularly when treating an oral disinsertion of more than 70°–90°, stretching of the sponge should be avoided. Why?

▶ To avoid provoking fishmouthing.

In general, an oral disinsertion represents an old detachment, as evidenced by pigment demarcation lines or intraretinal cysts. But before viewing the retina, already with slit lamp examination you will find "tobacco dust" in the vitreous. In general, there will be no vitreous detachment, because oral disinsertions are found in the younger age group. Even after nondrainage this old detachment will reattach as fast as a recent one. This favorable result applies of course only under the premise that the buckle is positioned adequately.

● **The following can be used as a rule of thumb to make correct buckling of an oral disinsertion easier:**
- Mark the lateral borders of the disinsertion in a limbus distance comparable to that of the muscle insertion (7–8 mm).
- The most posterior mark has to be made precisely, and it must be remembered that another 2 mm need to be added when centering the mattress suture on the marks.

Most of the time, oral disinsertions are detected in young patients. In these eyes, old fluid will therefore not imply delayed absorption; instead the retina will reattach overnight.

? Why?

▶ Because the younger patient has a well-functioning choroid and pigment epithelium.

Another question that might arise is:

? Why are the surgical results of an oral disinsertion detachment so favorable in comparison to those of giant tears?

▶ Because (as will be remembered) the posterior edge of the tear is not longer than its anterior edge.

? What does this imply?

▶ *In an oral disinsertion, there has been no additional radial tearing.*
However, there is radial tearing in a giant tear, which in fact represents a giant horseshoe tear, and it is precisely this radial tearing that causes problems when being buckled circumferentially.

8.11 Application of Cerclage

The cerclage was developed by Schepens et al [22], based on earlier work by Arruga [23]. It is an operation in which surgery (indentation) is carried out on the entire circumference of the eye.

? Why is this maximum operation still in use?

▶ As mentioned earlier, the primary intention in this procedure was "to wall away uncertainties in the periphery."

This was justified at a time when modern techniques for meticulous preoperative study of the retinal periphery were not available. This situation changed when binocular indirect ophthalmoscopy with scleral depression [22] and biomicroscopy with various direct and indirect contact lenses [24–28] as well using depression became fully integrated into the armamentarium of preoperative diagnostic techniques. Another intention underlying cerclage became invalid due to the nondrainage technique, which eliminates the need to compensate for lost intraocular volume by encirclement.

? So why is cerclage still given consideration?

▶ The reason is that some surgeons believe they are carrying out a maximum operation with a cerclage, and incorrectly assume that they will also have a maximum of success.

This reflects a mistaken conviction, dating from almost 30 years ago, that one can create a "new ora serrata", i.e., a new fixating edge for the retina, thus excluding all of the doubtful areas (undetected breaks) in the periphery. The idea behind this operation was that a cerclage would fulfill this task and provide a prophylactic measure against future breaks. A subsequent clinical study invalidated this assumption.

● The rate of redetachment after minimal buckling in the absence of a cerclage was not higher during a long-term follow-up period of 15 years [3].

A 3rd reason for applying a cerclage is also becoming less and less significant—i.e., to counteract a severe vitreous traction in a PVR detachment. In patients with this condition, the frequency of which lies in the range of less than 2%–5%, expert vitrectomy with membrane peeling has replaced the need for a cerclage.

? In the state of art today, are there any indications left for applying a cerclage, then?

▶ Almost none when treating a rhegmatogenous detachment.

It should be recalled that a cerclage is not indicated or justified merely because the surgeon has not invested sufficient time in a meticulous preoperative study of the detachment.

● **Consequently, the less one studies and learns about the details of the detachment, the larger the operation has to be in order to cover "unknown" possibilities** (in a kind of polypragmasy policy).
  — It is better to study than to over-operate or re-operate on an eye.

● **Even a pseudophakic detachment with a secondary cataract is not per se a justification for performing a cerclage or a primary vitrectomy.**

● Instead, one should play on the full orchestra of indirect techniques for fundus examination (indirect binocular ophthalmoscopy and indirect contact lenses [28]) with depression. Give this analytic approach a chance to solve the problem of such a pseudophakic detachment, and spend as much time as needed on it.

? **Are there any indications still remaining for using a cerclage in the late 1990s?**

▶ The only indication remaining for a cerclage is a rare one (less than 1%–2%):
— **In an initially successful buckle that failed due to increasing traction.**

After the switch from cerclage with drainage to minimal buckling without drainage, in a series of 1 000 rhegmatogenous detachments operated on between 1970 and 1977 using segmental sponges without drainage, a cerclage was still applied in 4% of the first 500 patients [29].

? **Why in the early 1970s still a cerclage in 4%?**

▶ The use of cerclage in these detachments was due to what were still regarded "uncertainties in the periphery" (in fact, these were merely ***our*** *own "uncertainties"*) and due to the assumption that *"there must be traction"* (as ***we*** had concluded).

However, this approach changed in a subsequent series of 107 detachments operated on *between August 1979 and January 1980.* At that time, **none of the eyes underwent a cerclage operation** [30].

? However, if a cerclage is still applied for selected detachments, what aspects need to be taken into account?

▶ **One should try to constrict not more than 10%,** as this is sufficient to elevate the buckle (by about 1 mm), and this will not jeopardize the prognosis for the eye.

? But how do you obtain a 10% constriction with a cerclage?

▶ — To begin with, it should be recalled that the average adult eye has a circumference of 77 mm and an outside equatorial diameter of 22 mm [31].

Therefore:
- For a **10% constriction**, the elastic band has to be shortened by 7 mm
  (if drainage is used, the circumference must be measured beforehand).
- For a **15% constriction**, the band has to be shortened by 12 mm.

? What about myopic eyes?

▶ A myopic eye with an equatorial diameter of 25 mm requires only an additional 1 mm shortening for each 10% constriction.

As you might recall, the variation in ocular size can be largely neglected, since the change in circumferential shortening in the 10% to 15% range of constriction is small.

● **But you have to expect radial folds due to the decreased circumference of the eye, i.e., as a result of constriction by the cerclage** (Fig. 8.**30**).

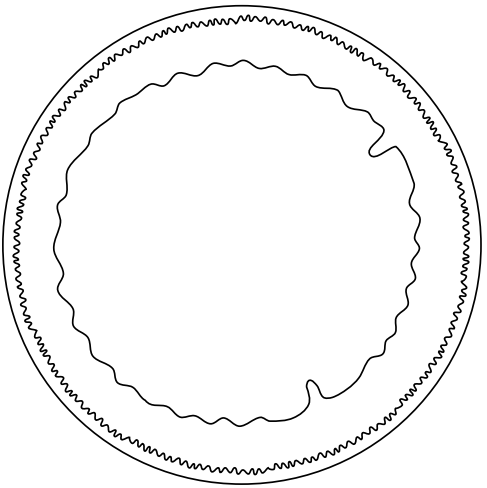


Fig. 8.**30** Reduction in the circumference of the globe due to constriction by a cerclage. The retina settles with radial folds, which often aggregate in the area of a tear, with subsequent posterior leakage.

8.11.1 Early Complications after Cerclage

At a constriction level of 10%–15% with a cerclage, no signs of anterior ischemia should be observed; however, one must be aware of these. They will be present after a larger constriction, manifesting as:

- **Signs of *anterior* ischemia:**
  - Fibrin in the anterior chamber
  - Asymmetric pupil
  - Uveitis
  - Hemorrhage into the anterior chamber or vitreous (a result of ciliary body constriction)
  - Hypertension or hypotension (choroidals, phthisis).

Although intraocular pressure has returned to normal levels, the circular band still has the appearance of being stretched. The living eye slowly responds to the residual pressure of the elastic element by elongation and by reducing its diameter (as can be confirmed by ultrasonography), with subsequent complications.

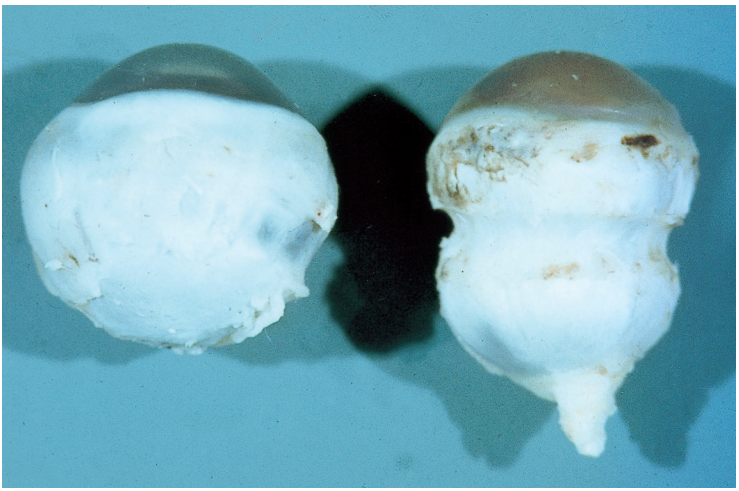


Fig. 8.**31** Late complications after cerclage. *Left:* Normal globe. *Right:* Deformed globe after cerclage (25% constriction). The living eye responded to the residual pressure of the elastic element by elongation (myopization) and reduction of its diameter. In this situation, there is a risk of decreased blood circulation (retinal and choroidal), subsequent decrease of regained visual function, and even scleral erosion.

8.11.2 Late Complications after Cerclage

The most important late complication after cerclage is posterior ischemia (Fig. 8.**31**).

- **Signs of *posterior* ischemia:**
  - Constricted visual field and diminished electroretinogram [10]
  - Decreased retinal and choroidal blood flow [8–12]
  - Reduction in 2-point discrimination [13]
  - Pigmentary dystrophy and diminished retinal sensitivity in comparison to the fellow eye as observed by Lincoff (he now cuts all the encircling elements of eyes treated in patients sent to his office [2])

Elongation of the eye
Scleral erosion (be aware of diathermy).

8.11.3 Conclusions

It should be realized that spending sufficient time preoperatively on diagnostic procedures to identify the break or breaks is a more favorable approach for the eye than performing a larger operation, such as a cerclage, which will not be capable of finding the missed breaks either. If, after meticulous study and thoughtful consideration, one still decides to use a cerclage, one should be rigid about the percentage of constriction to be allowed.

- Guaranteed close follow-up of the patient with a cerclage must be ensured, and one must decide early enough to cut the band (visual function!).

If use of a cerclage is selected only in order to compensate for the lost volume, e.g., due to an accidental puncture, then instead either use a **temporary catgut cerclage**, which will in addition elevate the buckle at no risk, or insert a **parabalbar balloon** and inflate it as needed, or—preferably—inject a bubble of **Xenon** [32], a gas with a half-life of only 6 hours, which avoids inducing a cellular reaction in the vitreous (reducing the risk of subsequent PVR).

? **If there are multiple breaks in a 3-quadrant detachment (1 break in each quadrant), should one carry out a "prophylactic" cerclage (Fig. 8.32)?**

▶ As discussed on Optimal Tamponade for Multiple Breaks, p. 163, the answer here is: **No.**

? **Another question that arises is whether one should apply a cerclage over an area of attached retina.**

▶ Again, the answer is: **No.**

It is better instead to select individual radial buckles, which at the same time represent a) an optimal tamponade for the tears and b) an extraocular minimal approach, not associated with the late complications reported after cerclage due to constriction.

- Thus, when treating a detachment that is not total, one should not include attached retina in the buckle—i.e., a cerclage should not be applied in such patients.

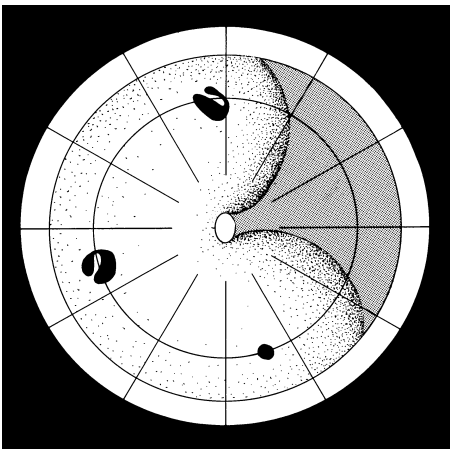
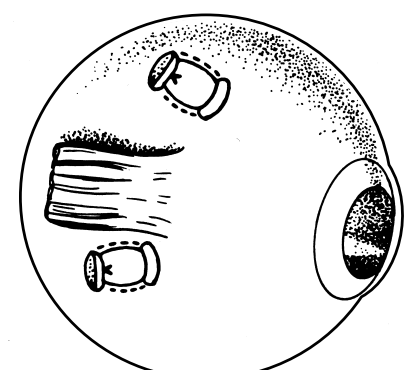


Fig. 8.**32** A 3-quadrant detachment with multiple breaks. 3 different approaches to buckling are shown here, involving increasing levels of morbidity: minimal buckling, more extensive buckling, and circular buckling (cerclage). **a** The detachment, with 1 break in each of 3 quadrants. The breaks are over 2 clock hours apart; no additional breaks were found in the remaining detached retina.



b Minimal buckling, at the same time implying optimal tamponade for the tears, consisted of applying 3 individual radial sponges to the breaks, without drainage. The retina reattached. *No late complications or reduction in the regained visual function are to be expected in comparison to the fellow eye.*

When there is a total detachment with breaks in all 4 quadrants (a rare finding), a cerclage can still be avoided by defining an area of at least 2–3 clock hours in extent that does not harbor a break and therefore does not need to be buckled.

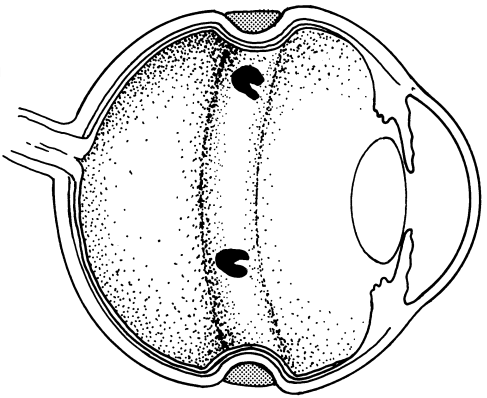
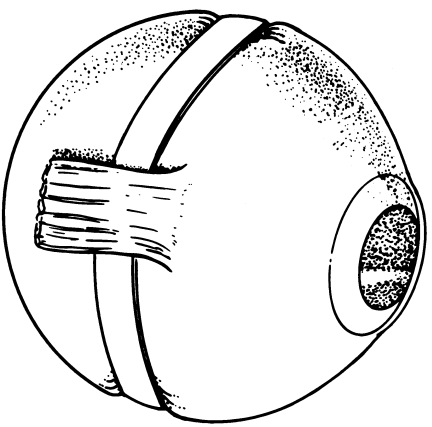


Fig. 8.**32 c** More extensive buckling for the detachment in Fig. 8.**32 a** might consist of a circumferential sponge buckle of 8 clock hours in extent, possibly still without drainage. The circumferential buckle would not represent an optimal tamponade for the horseshoe tears, and in inexperienced hands such a large sponge (3 × 5 mm) would therefore be necessary. However, a buckle with a smaller diameter—still providing sufficient tamponade—would be a better solution, if at all applied.



d Most extensive circumferential buckling as treatment for the detachment in Fig. 8.**32 a**, a cerclage (with or without radial elements, or instead using a wider encircling element to achieve sufficient tamponade of the tears), might be associated with late complications due to constriction of the globe, and would require drainage of subretinal fluid, adding another degree of morbidity.

? Why is a circumferential buckle of 10 clock hours in extent preferable to a closed circumferential buckle, i.e., a cerclage?

▶ To avoid the risk of the complications reported after using a cerclage [31].

Bearing all of this in mind, and as one's experience in segmental buckling without drainage grows, it will soon be realized that almost all rhegmatogenous detachments can be treated primarily with extraocular minimal buckling.

- **It is only in rare instances that a cerclage (less than 1%–2%) or a primary vitrectomy (2%–5%) will be a useful approach:**
  - Over 90% of detachments can be treated with minimal extraocular surgery, and in these patients the eye and its regained visual function are not at risk in the longer term [3].

8.12 Retinal Detachment: An Emergency

During the last 60 years, retinal detachment surgery has concentrated primarily on anatomical reattachment. The rate of reattachment rose from 40% in the 1930s to over 90% (up to 99%) in the 1990s—a considerable success in the context of surgical techniques.

- **However, reattachment is one thing, and visual function is another**—all the more so today, when life expectancy has risen tremendously, making postoperative long-term visual function all the more important.

In 1967, one of the author's patients stated:

> "Well, doctor, you and your colleagues are always saying that my retina is fine and the surgery was successful" (one should never use the word "successful" with a patient!) "but, to tell you the truth, I don't think the retina is fine—I can't see, and I cannot read."

The patient's words were very true; and from then on, patients with a reattached retina were always asked in detail about the quantity and quality of the visual function regained. There were considerable differences among them with regard to the amount of visual acuity and the quality of color vision, and there were complaints about "not seeing print clearly."

Since 1967, the author has focused her studies on this problem, initially with the support of Prof. H. K. Mueller in Bonn, and thereafter encouraged by Prof. H. Lincoff in New York, during several years of training there. Today, everyone would undoubtedly agree that a 100% reattachment of the retina and macula does not necessarily imply a 100% return of visual function.

Reattachment of the retina implies recovery of peripheral vision, but does not in itself guarantee a complete recovery of macular function. It will be recalled that the macula is privileged in having the densest arrangement of cones, and once this area becomes detached, multiple forms of damage, some of which may even be permanent, will result.

Between 1970 and 1973 we made the following observation. If a macula was detached for several weeks, visual acuity ranged only between 20/100 and 20/200, despite reattachment.

- For this reason, we postulated in 1974 that **the following forms of retinal detachment should be declared to be emergencies** [33, 34]:
  - An acute bullous detachment approaching the macula
  - A detachment with a partially or completely detached macula

? What does an emergency in retinal detachment surgery mean?

▶ A rhegmatogenous detachment that is declared to be an emergency requiring hospitalization becomes a **surgical emergency the moment the diagnostic problems are solved, i.e., as soon as the break or breaks are found.**

8.12.1 Clinical Study

To analyze the preoperative factors influencing postoperative visual function, a prospective analysis was carried out in 266 retinal detachments, operated on between October 1976 and July 1978. In all of the patients preoperative and postoperative macular function was tested for qualitative and quantitative responses [35–37]. The retina was reattached in these patients using cryopexy and an extraocular minimal technique—i.e., a sponge sewn onto the sclera in the area of the break or breaks without drainage of subretinal fluid.

When it was found that the preoperative state of the macula will affect postoperative function, 5 categories of retinal detachments were defined preoperatively (Table 8.**2**). Groups II–V refer to 4 different states of macular detachment, involving different extents (groups II and III) and different heights (groups III, IV, and V).

8.12.1.1 Visual Function

The following visual functions were tested: Visual acuity, light-difference threshold, color vision, and metamorphopsia at different times after surgery. Group I, with preoperatively attached macula, served as a control group, as it was capable of showing the effect of the operating procedure on macular function and defining the time necessary for postoperative recovery, which ranged between less than 1 week and 1 month.

Table 8.**2** The 266 retinal detachments were divided preoperatively into 5 groups on the basis of the extent of the detachment in the posterior pole.

Group	Extent of retinal detachment		n
I	Macula attached		70
II	Partial detachment of the macula		28
III	Total detachment of the macula		23
IV	Total detachment of the macula and partial detachment of the retina around the disk		99
V	Total detachment of the macula and the retina around the disk		46

▶ Visual acuity

This was tested with the Idem projector with decimal division. Significant differences were found in the postoperative changes among groups II–V, with the 4 different states of macular detachment yielding statistically different visual acuities. On the basis of the 196 patients with preoperatively detached macula of various degrees, the

- **Postsurgical visual acuity showed a mean of:**
  20/30 in group II
  20/40 in group III
  20/50 in group IV
  20/60 in group V [35, 36]

- **These results tended to confirm that:**
  - **The extent and height of the macular detachment**
    affect postsurgical visual acuity.

It was also found that the postsurgical visual acuity is influenced by:

- **– The duration of the macular detachment:**
  The time within 1 week appeared to be critical for macular recovery.

If the macula was detached for less than 1 week, the resultant visual acuity was optimal, and substantially better than if the duration of detachment was longer than 1 week.

Macular recovery after a 6-month to 1-year detachment only differed slightly from the recovery after 2 weeks.

When the postoperative visual acuities of all 196 patients with detached macula were analyzed for recovery at 2 months and 1 year, a rapid increase in visual acuity was found within the first 2 months in all of the groups, followed by a lesser increase up to 1 year.

The mean visual acuity in all 4 degrees of macular detachment was better after 1 year than after 2 months.

- **– The age of the patient also influenced the functional results.**

When the 196 patients with detached macula (groups II–V) were divided into 2 groups, i.e., those above and below 60 years of age, the comparison showed that while there was no statistical difference in the recovery up to 2 months,
Recovery after 6–12 months was significantly poorer in the age group over 60 years.
When the 196 patients with detached macula were divided into 3 refractive groups, it was found that the mean postsurgical recovery of visual function depended on:

- **– The degree of myopia:**
  When myopia was more than −6 dpt, the recovery of visual acuity was less.

The study did not include any patients with ophthalmoscopic evidence of myopic degeneration in the macula.

? What do these results imply for detachment patients?

1. **Extent and height** of macular detachment affect postsurgical visual acuity.
2. **Duration** of macular detachment comes next in order of importance. The resultant visual acuity in a macular detachment that has persisted for less than 1 week is significantly better than in one that has persisted for 1–2 weeks. Surprisingly, the resultant visual acuity in a macular detachment that has persisted for 1–2 weeks is not significantly better than that after 2 weeks to 1 year.
3. **Age of the patient** is the next factor influencing the visual results. Patients over 60 years of age recover less visual acuity during a period of up to 1 year postoperatively. In a younger patient, i.e., under 60 years, an improvement can be still expected after 1 year.
4. **Myopia** is affecting postoperative visual acuity. Recovery is poorest in patients with myopia of more than −6 dpt.

▶ Light-difference threshold

The light-difference threshold was tested as the second postoperative parameter of macular function [35, 36]. The results confirmed the validity of the presurgical grouping of macular detachment—i.e., its extent and height. In addition, they confirmed that the duration of macular detachment, the age of the patient, and the degree of myopia influenced the postsurgical recovery of function—findings already confirmed in relation to postoperative visual acuity.

▶ Color vision

Postoperative disturbances in color vision were described by Gaillard [38], François and Verries [39], and others. In our series of patients, color vision was tested using the Farnsworth panel d-15 test [37]. Three months after retinal reattachment, half of the patients had defective color vision; in the majority of patients, it was a trito-disturbance. When the patients were divided into 3 age groups—those under 40 years, 40–60 years, and over 60 years—the disturbances in color vision were found to be most prominent in the oldest age group. When patients under 60 were compared with those over 60 years of age, a significantly larger number of postsurgical disturbances in color vision were found in the age group over 60 years.

- **Color vision recovered more slowly and less completely than visual acuity.** After 3 months, only **1 in 2 patients were found to have normal color vision, and only those under the age of 60.**

A correlation was found between postsurgical color vision disturbances and visual acuity after macular reattachment. Patients with postoperative color vision disturbances had a mean visual acuity of 20/100. Patients without disturbances had a mean visual acuity of 20/40. A color vision deficiency was present in every patient whose visual acuity was below 20/100.

- Conversely, **no color vision deficiency was present when the visual acuity was above 20/30.**

▶ Metamorphopsia

Metamorphopsia was tested using the Amsler chart. The disturbances manifested as distortion and blurring of the lines in the Amsler chart. The lines of the grid appeared to the patient "as if they had been drawn by hand" [35, 36].

- **Postsurgical metamorphopsia occurred in all patients with a previous macular detachment, this time independently of age, and it was still present at the end of 1 year.**
  Metamorphopsia could be detected even when visual acuity of 20/20 and normal color vision had been recovered.

8.12.1.2 Conclusions

Of the 4 visual functions tested after macular reattachment:

- **Metamorphopsia represented the most sensitive indicator of an episode of previous macular detachment.** Metamorphopsia can be regarded as a ***"scar in the Amsler grid."***

Metamorphopsia therefore represents a kind of memory of a previous macular detachment, and this was even true for patients in whom there was partial involvement of the macula (Fig. 8.**33**)—i.e., there was a sector-shaped metamorphopsia in the presence of fully recovered visual acuity without detectable color vision disturbances (Farnsworth panel d-15 test).

Visual acuity improved in all patients immediately after macular reattachment and increased rapidly for 3 months, but thereafter it was slow and minimal. The recovery of color vision took place later than that of visual acuity and was less frequent, only being found in patients under the age of 60.

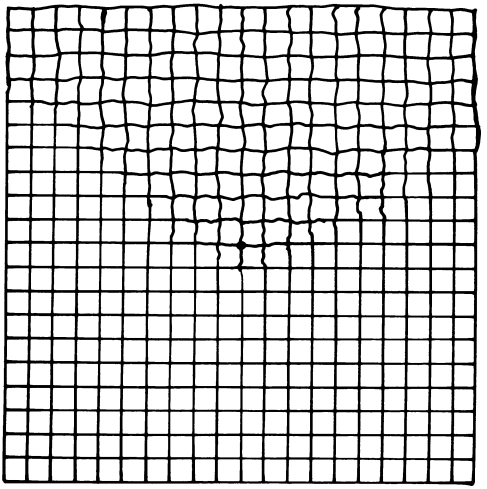


Fig. 8.**33** Postoperative Amsler grid in a 39-year old patient after repair of an inferior detachment (oral disinsertion) that appeared for treatment when the macula detached. Postoperatively, the patient had a visual acuity of 20/20 and no detectable color vision disturbances. However, there was a superior wedge of distortion in the Amsler grid that correlated with the previous extent of the macular detachment. The remainder of the grid was unaffected.

? Which of these findings have important implications for the clinical management of detachment patients?

▶ Apart from the prognosis in retinal reattachment, the implications for clinical management are as follows:

- While neither the age of the patient nor the myopia can be influenced by treatment
- **The extent and duration of a macular detachment can be modified by immediate hospitalization of the patient** — all the more so when treating a patient with a macular detachment
  - that has persisted for less than 1 week, or which is in
  - patients over 60 years of age or in
  - myopes over −6 dpt.

- **Binocular patching and bed rest to reduce the height and extent of the macular detachment, and carrying out surgical repair at the earliest moment for reattaching the macula,** therefore seem appropriate.

- **All of this provides justification for the requirement** [33, 34] **that some retinal detachments should be assigned:**
  - **Emergency status** on entering the hospital and should receive
  - **Priority position** on the operating schedule the moment the diagnostic problem of the detachment is solved.

8.13 Residual Retinal Detachment after Nondrainage Operation

? What should be done if there is residual fluid after a nondrainage operation the day after surgery?

First, the preoperative diagnostic procedures and surgery should be reconsidered. One may still be convinced that all of the breaks were found and sufficiently buckled; however, the next morning the retina is still partially detached [40].

? What went wrong? Is this a failure?

▶ No, not necessarily. But a differential diagnosis of the fluid is needed first.

? What will the guidelines be?

As already practiced in a primary detachment, the quality of its surface and contours should also be analyzed in this residual detachment. Listed below are the various types of a residual detachment that must be considered [41].

8.13.1 Differential Diagnosis

8.13.1.1 Convex residual detachment

The break is reattached on the buckle, but there is a residual detachment. It has convex contours and a convex surface. There are 2 possibilities here:

- Circular residual detachment extending to the ora serrata
- Spindle-shaped convex residual detachment

▶ **Circular residual detachment extending to the ora serrata**
The patient in Fig. 8.**34a** shows such a finding, the day after surgery (Fig. 8.**34b**).

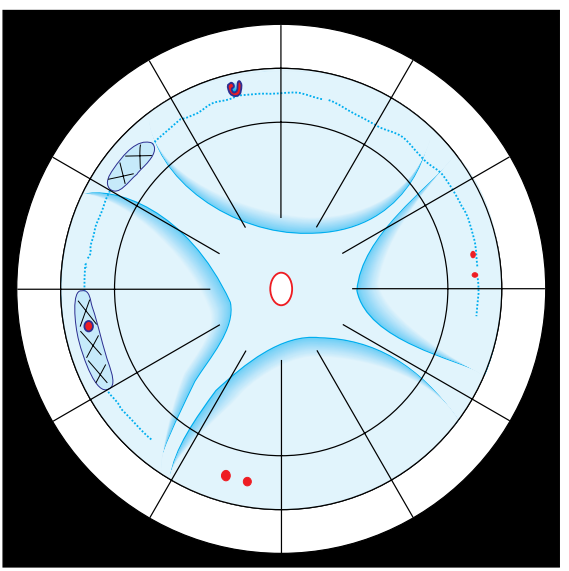


Fig. 8.**34a** A total bullous aphakic detachment. There is a horseshoe tear at 11:30, with traction lines in the periphery, representing adhesions of the vitreous base. The "hole" in lattice degeneration is a pseudohole, since it is located within the lattice. There are several petechial hemorrhages due to previous vitreous traction; these do not represent holes.

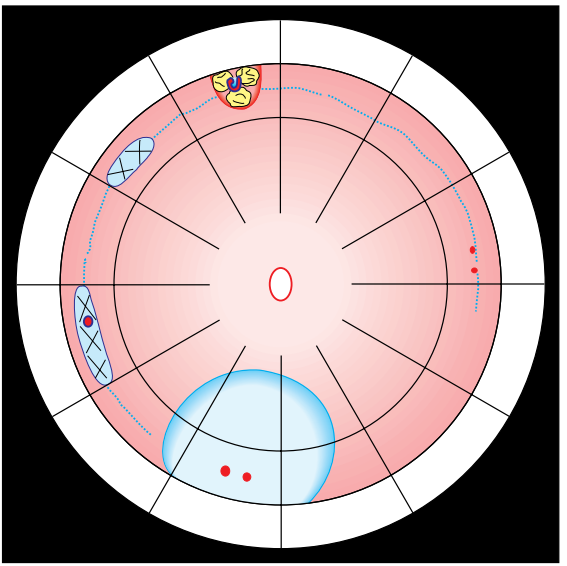


Fig. 8.**34 b** *Convex inferior residual detachment* after the tear at 11:30 was buckled. Residual detachment is typified by its circular contour and the way in which it rounds off as it approaches the ora. The patient has to sleep in an elevated position to prevent pooling of fluid into the macula overnight. The residual fluid had disappeared after 3 days.

? Is this a residual *rhegmatogenous* detachment?

▶ No.

? In what way does it differ?

▶ The answer lies in its contours.

Its curvatures should therefore be critically analyzed. In contrast to a rhegmatogenous detachment, the borders of this residual detachment round off as it approaches the ora serrata—i.e., it curves back like a circle. It does not show the flat curvature toward the ora that a rhegmatogenous detachment would; in contrast, **this detachment is almost round, like a cyst.** To confirm the diagnosis, another break still has to be excluded.

? What will the treatment consist of? Double patching and positioning the patient?

▶ No.
- Instead, **mobilize the patient** without restrictions. The fluid will remain inferior due to gravity when the patient is in an upright position.
- However, the patient should be asked to **sleep with the head elevated.** This will prevent pooling of the mobile fluid into the macula overnight.

▶ **Spindle-shaped convex residual detachment** (Fig. 8.**35**). This configuration of convex residual detachment does not extend to the ora. Instead, it collects in a spindle shape beneath a major vessel distribution.

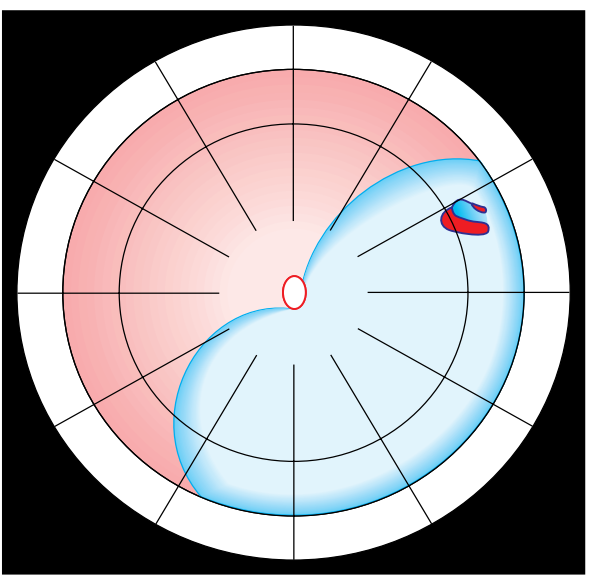


Fig. 8.**35a** A 2-quadrant detachment in a 70-year old patient. There is a horseshoe tear at 2 o'clock.

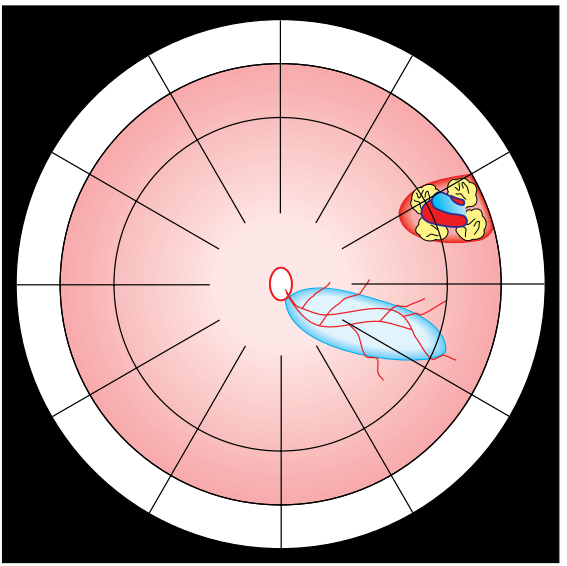


Fig. 8.**35 b** *Convex, spindle-shaped residual detachment* is seen after buckling the horseshoe tear at 2 o'clock. This residual detachment does not extend to the ora serrata. It lies beneath a major vessel distribution, and the macula is reattached. The patient was mobilized; the residual fluid disappeared spontaneously after 9 days.

? What should be done?

▶ Once again nothing needs to be done here except **mobilize the patient**.

Both of the above convex residual detachments may take a few days to absorb. It is typical that they do not increase in spite of the patient being mobilized, but spontaneously decrease. There is no need for surgical intervention.

8.13.1.2 Concave residual detachment

In this retinal detachment, too, the break has been sufficiently tamponaded, but there is residual fluid with different qualities (Fig. 8.**36**).

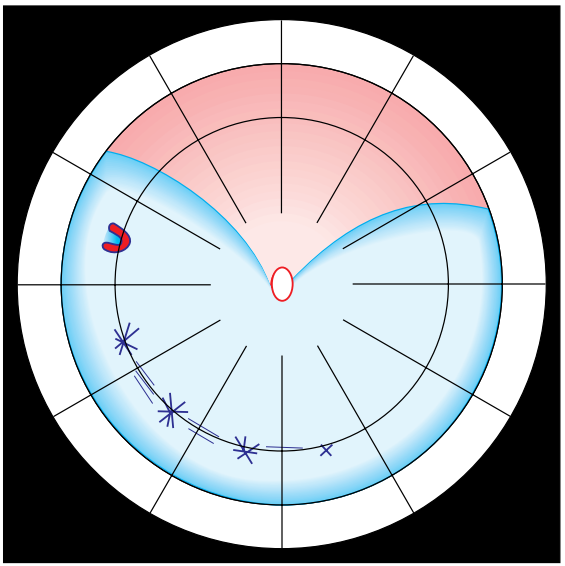


Fig. 8.**36a** A 3-quadrant detachment with starfolds. There is a horseshoe tear at 9:30, and starfolds are seen in 2 quadrants. In spite of the starfolds, the detachment has convex borders, indicating its rhegmatogenous quality.

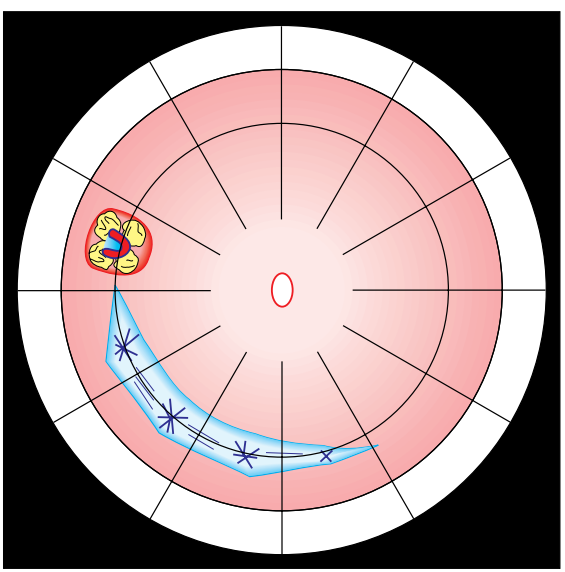


Fig. 8.**36 b** *Concave residual detachment,* located in the area of the starfolds and not extending to the ora, after buckling of the break at 9:30 without drainage. After 6 months, the starfolds had attached, and were hardly visible after $1^1/_2$ years. The retina remained attached during 16 years.

? Is this a failure?

▶ No.

? What is different here?

▶ Analyze once again the residual detachment with regard to its contours, surfaces, and this time once again its location in relation to the ora serrata.

When the patient lies flat, the fluid will not shift as it would have done in the convex residual detachment discussed above. By contrast, this detachment has **concave contours and concave surfaces**, and it **does not shift** when the patient is positioned.

? What else is specific about this retinal detachment?

▶ In contrast to a rhegmatogenous detachment, it does not extend to the ora serrata; instead, it is limited to an area of starfolds with connecting traction lines.

? What should be done?
Should the patient be double patched and laid flat? Or should the patient be advised to sleep with the head elevated overnight?

▶ – Neither of these propositions.
– Instead, **mobilize the patient** without restrictions.

This detachment, which is fixed by traction, will not even pool into the macula when the patient lies flat. It will slowly regress at the same rate as the PVR regresses. No surgical intervention is needed.

8.13.1.3 Convex rhegmatogenous residual detachment

This finding represents an only partial reattachment due to failure. The retinal detachment has postoperatively taken on a new shape after buckling of the break. There can be 2 reasons for failure:

– Another break
– Leakage from a break due to inadequate buckling

▶ Another break

In this detachment, an accompanying hemorrhage obscured the view during surgery (Fig. 8.**37a**). Postoperatively, the retina only partially reattached after a nondrainage operation. The residual detachment again has convex borders and a convex surface, and it extends to the ora serrata (Fig. 8.**37b**).

? Why is it not just a convex residual detachment? Why must it be harboring a break?

- There has to be a break present because the borders do not round off as it approaches the ora serrata
- Instead, it shows a flat curvature toward the ora.

This indicates that it is just another rhegmatogenous detachment with a smaller extent:
It will **not regress, but is more likely to progress.**

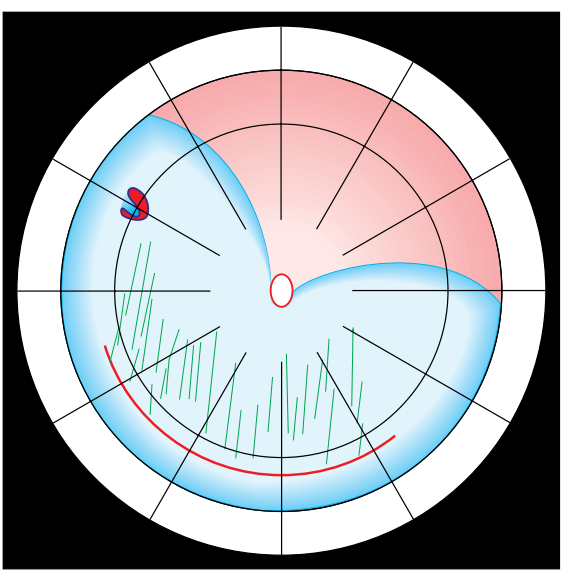


Fig. 8.**37a** A 3-quadrant detachment with vitreous hemorrhage. There is a horseshoe tear at 10 o'clock, corresponding to Rule 1 of how to find the primary break (see p. 14). Due to vitreous hemorrhage, the entire retina was not visible for examination.

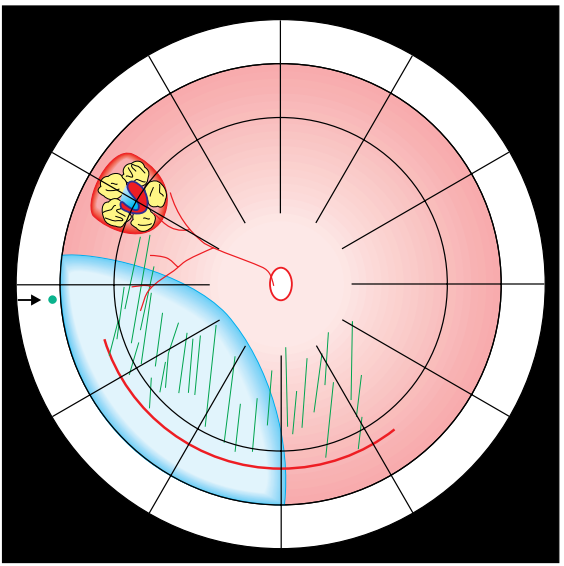


Fig. 8.**37 b** *Convex rhegmatogenous residual detachment (surgical failure)* is seen after buckling of the break at 10 o'clock without drainage. The contour of the detachment had changed—i.e., the retina only reattached partially. The residual fluid is not due to delayed absorption, but due to an overlooked break. It is a residual rhegmatogenous detachment, typified by its *flat curvature toward the ora.* – After a meticulous search, a tiny break in the anterior bifurcation of the vessel was found, only detected using the biomicroscope with depression. To ensure detecting it with indirect ophthalmoscopy during surgery, preoperatively a laser mark was placed – by applying depression – in the radian of the hole in the pars plana (see arrow).

The new contour of this rhegmatogenous detachment will guide one to the defined area in which the break will be found according to the Rules (see Chapter 2.2 The 4 Rules to Find the Primary Break, p. 13.)

When the missing break has been detected, the detachment becomes even more of an emergency if the macula is still detached, or at risk of redetaching.

▶ **A leaking break due to an inadequate buckle** (Fig. 8.**38**). Postoperatively, the entire retina appeared to be reattached. However, on the 3rd day, a partial redetachment developed, origi-

nating at the lateral buckle side. This lateral portion of the break was leaking, causing this **increasing residual rhegmatogenous detachment**. After the tamponade had been enlarged to close the leaking break (see Part 2: Chapter 14. Reoperation of Retinal Detachments without Drainage), the residual fluid disappeared.

In both types of rhegmatogenous residual fluid presented above, the patient had to be double patched and positioned until the causative break (leaking, or yet to be detected) was tamponaded.

? **Why are these precautions and immobilization of the patient necessary?**

▶ Otherwise the residual detachment will progress, endangering the partial reattachment or risking macular involvement.

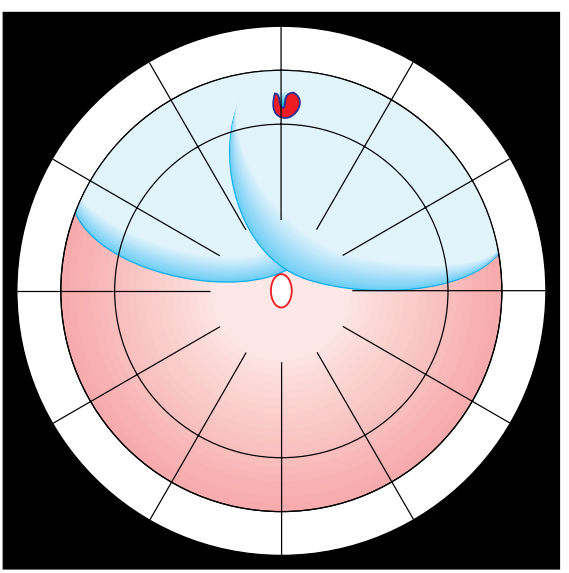


Fig. 8.**38a** A 2-quadrant superior bullous detachment. There is a horseshoe tear at 12 o'clock (rectus muscle!).

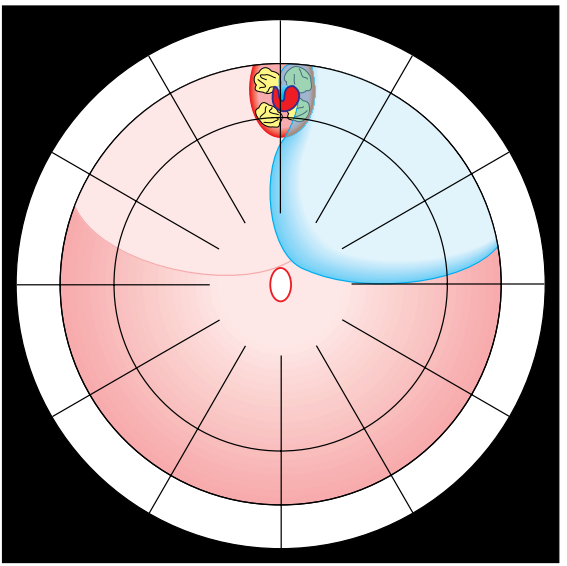


Fig. 8.**38 b** *Convex rhegmatogenous residual detachment (surgical failure),* due to lateral leakage from a break after an inadequate radial buckle of the tear at 12 o'clock. Here again, the contour of the detachment had changed, and the retina only partially reattached. The residual fluid is not due to delayed absorption, but due to leakage of an inadequately tamponaded tear. The residual rhegmatogenous detachment is within its previous extent, and *extends to the ora.* After the tear was sufficiently tamponaded, the residual detachment disappeared.

8.13.2 Clinical Study

There were 107 primary rhegmatogenous detachments, in which surgery was carried out with segmental buckling and without drainage (sponge or balloon) in the area of the break or breaks and which were analyzed with regard to the frequency of postoperative residual detachments [30]. After the primary operation, the retina was completely reattached in 99 eyes, partially reattached in 4, and detached in a further 4 eyes.

? How often was residual fluid present the day after surgery?

Table 8.3 Delayed absorption (n = 34) after segmental buckling without drainage in 107 retinal detachments.

Complete postoperative reattachment	n
1–3 days	17
4 days–1 month	9
2–3 months	6
4–6 months	2

In this series of 107 detachments treated without drainage, postoperative fluid represented an operative failure in 4 eyes (3.7%), and it was a residual detachment that disappeared over time in 34 eyes [41]. The differential diagnosis of the nonrhegmatogenous residual fluid in these 34 eyes identified 17 instances of convex residual fluid, and 17 of concave residual detachment.

? How long did it take for the residual nonrhegmatogenous (convex or concave) detachments to disappear?

In 17 eyes it disappeared after 1–3 days, in 9 after 4 days to 1 month, in 6 eyes after 2–3 months, and in 2 eyes after 4 or 6 months (Table 8.**3**). In some patients with a concave residual detachment (recall that there were 16 eyes with preoperative PVR grades C1 or C2), the starfolds finally disappeared, and were hardly visible at all after several years.

8.13.3 Summary

When carrying out detachment surgery without drainage, one has to be aware that parts of the retina will still be detached in some patients on the 1st day after surgery.

At this point, it is important to distinguish between delayed absorption and surgical failure:

- **Convex residual detachment,** caused by delayed absorption, is more likely to be found in a pseudophakic eye, in the presence of choroidals, in a highly myopic eye, or in the presence of atrophic

choriocapillaris. In these situations, it is important to wait, and the patient can be mobilized. However, **if there are any doubts** about whether the diagnosis is or is not one of surgical failure, **proceed as follows:**
Mobilize the patient, and if there is no increase, but rather a decrease, in the detachment, the diagnosis of "delayed absorption" is correct.

- **Tractional residual detachment.** In addition, in a detachment with preoperative moderate PVR, it can be expected that a tractional residual detachment will be found postoperatively. However, one must be sure that it has concave borders and a concave surface. Here, too, it is essential to wait, mobilize the patient, and to *avoid anything that might re-stimulate an already regressing PVR.* This means avoiding an unnecessary reoperation. *Despite mobilization, a tractional detachment might not increase, but finally decrease.*
- **Rhegmatogenous residual detachment.** However, if a rhegmatogenous residual detachment—which has borders with a flat curvature toward the ora, and is progressive—is present, then *an immediate reoperation is indicated. "Immediate" here means as soon as the undetected break is found.*

In this situation, the reoperation can also be aimed only at treating the break, rather than the extent of the detachment. This would imply limiting surgery again to the area of the break, representing a minimal extraocular approach.

- **In an eye undergoing reoperation, one should only carry out as much surgery as needed, and no more.**
- One should not be tempted to carry out prophylactic or prospective surgery merely because it is a reoperation (see Part 2: Chapter 14. Reoperation of Retinal Detachments without Drainage).

8.14 Complications

Since the nondrainage technique (with elastic segmental buckles) avoids the need to drain subretinal fluid, it prevents the risk of intraocular complications, such as hemorrhage, choroidals, bacterial

infection, incarceration of retina and vitreous, as well as the need to restore pressure using an intraocular injection.

The only complications that remain with minimal extraocular buckling, are extraocular and reversible.

This is perhaps the most cogent argument in favor of the non-drainage procedure. When cryopexy is practiced with the usual care, cryopexy does not lead to intraocular complications (see Chapter 7, p. 93).

However, when carrying out cryopexy one must always bear in mind the following points:
- Do not overfreeze
- Limit freezing to the breaks
- Be restrictive about diagnostic freezing:
  Never allow cryopexy to compensate for "uncertainties" about the retinal detachment.

When it is used with these precautions, cryosurgery will not add complications to the surgery.

? What should be done if an accidental puncture occurs while the intrascleral sutures are being placed?

▶ Never panic. Instead, act immediately and in a well organized way, and take the best possible actions in this situation:
- First, move the patient's head to a position such that a possible hemorrhage is not able to pool into the macula.
- Leave the "intrascleral" suture temporarily in place, but place an additional limb of mattress suture further away from it, i.e., outside of the perforation site.
- Now tie the enlarged buckle over the marked area including the drainage site. This prevents fluid from draining, and at the same time provides support for the perforation site.
- After that carefully pull the limb of the "intrascleral" mattress suture out.

? Why, once the eye is perforated, should one not drain all the way, but instead only partially?

▶ This is in order to reduce the complications of complete drainage and to have subretinal fluid left.

? Why?

▶ Because when the retina is reattached the next morning, it will be known for certain that all of the breaks have been buckled sufficiently.

Now it will be recalled, complications can be avoided by:
- **Performing well-monitored cryosurgery—or, if too much coagulation is needed, completing it postoperatively by laser coagulations when the retina is reattached.**
- **Avoiding drainage.**

? Which complications are still associated with the extraocular minimal buckling operation [42]?

▶ These are extraocular and in connection with the buckle:
- Sponge extrusion/infection, in less than 1% [30] (see Chapter 8.4, p. 128).
- Diplopia (under 1% since special care is taken in postoperative ocular motility training (see Chapter 8.5, p. 138).

A clinical study was carried out in 1 900 patients who underwent surgery with segmental buckling and without drainage between 1970 and 1977, with 900 patients treated in New York and 1 000 by the author's group [43, 44]. The only differences between the 2 institutions were that our group's patients were also treated postoperatively in addition with 4 000 000 units of penicillin daily for 5 days; local antibiotics were given in New York for 1 week, and in our series for 3 weeks.
There were no statistically significant differences between the 2 groups of patients treated with or without systemic antibiotics.
In this study, using the Lincoff sponge I [43, 44], the infection rate was at 2,7%.

Whereas in a later study in which the **Lincoff sponge II [30] was used instead, the infection rate fell to under 1%.**

8.14.1 Early Signs of Buckle Infection

These occur **within the 1st week,** and are due to virulent organisms, such as *Staphylococcus aureus* and *Proteus mirabilis.*

The symptoms are:

- **Sudden deep pain** in the eye.
  This **can be confirmed** by locating the pain in the area of the infected buckle, which is done by using a Q-tip over the lid to depress the eye, first in an unbuckled area and then in the buckled one. Touching the latter area will inflict severe pain, and great care should therefore be taken.
- Sudden **increase in postoperative chemosis.**
- A **hemorrhage** or **whitish mass** (with an appearance like a heavy laser or cryopexy lesion), or an accumulation of **white cells over the buckle**.
- A **subconjunctival hemorrhagic mass**. This may not be visible when a very posterior buckle has been used.
- Some days **later, a fistula with hemorrhagic or purulent secretion.**

8.14.2 Late Signs of Buckle Infection

These arise **after months to years,** and are caused by *Staphylococcus epidermidis.*

The symptoms are:

- Pain
- Fistula
- Subconjunctival hemorrhage due to a granuloma (Fig. 8.**39**).

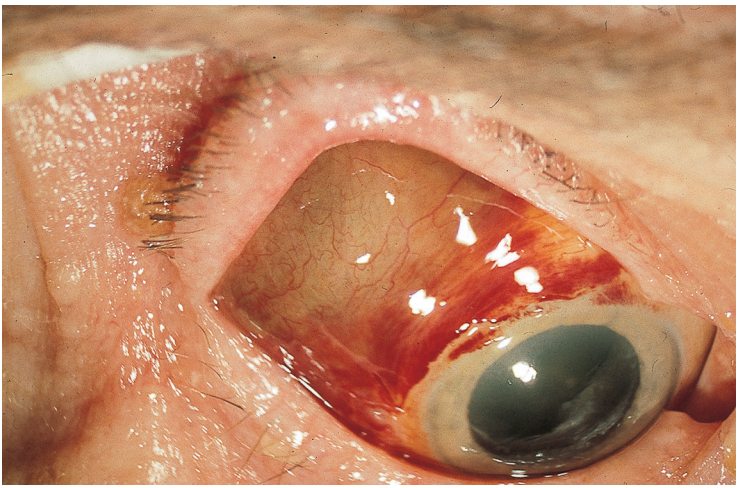


Fig. 8.**39** An eye 6 months after placement of a radial buckle (7 mm sponge). A hemorrhagic mass is visible under the conjunctiva, but there is no fistula or secretion. Slight tenderness is present in the area of the sponge, and when viewing the retina, there is a small preretinal hemorrhage in the area of the buckle. The *sponge and sutures were removed,* and were found to have been surrounded by hemorrhagic granulomatous tissue, typical of *Staphylococcus epidermidis,* which was identified in the intraoperative culture. After buckle removal, the retina remained attached, and the eye settled down.

? What should be done or not done? That is the question.

▶ **Do not close a fistula using conjunctival sutures.**
- This is because, as long as the parabulbar infection is "drained" via the fistula, the patient's problem has not been worsened, and the eye is not put at risk.
- Systemic or local antibiotics will not cure this sight-threatening problem; however, the best that antibiotics can achieve is temporary relief.

- **Instead, remove the explant *with sutures* immediately (on an emergency basis in a patient with an early infection).**
  - Prior to surgery, check the break to see whether additional laser lesions might be needed.
  - Intraoperatively, before rinsing the operative field with an antibiotic solution, be sure to take a smear and send it for culture and antibiogram.

As soon as the infected buckle is removed, the orbit will become sterile after 2–3 days, even without antibiotics [45]. However, if there are any early manifestations of infection, additional systemic antibiotics can be prescribed for 3 days, postoperatively.

With regard to *Staphylococcus epidermidis,* our belief is that it only acts as a pathogen in the presence of silicone explants. This observation has recently been supported by similar experiences with implantation of other silicone structures—e.g., in joint replacement, mamma prostheses, and heart valve replacement.

After removal of the infected buckle with sutures, the eye will settle down, and the retina will remain attached—but only if the supported break was sealed off sufficiently. In the few patients in whom explants have had to be removed, the retina remained attached [29].

? What should one do if the retina redetaches after removal of the buckle?

- Double patch the patient for 2 days to prevent a progression of the detachment into the macula. After 3 days, the break can be re-buckled without the threat of re-infection.

? What are the predisposing factors for buckle infection?

In our series of 1 900 patients, it was found that infection occurred in eyes with multiple sponges and long circumferentials, as well as in those in which a reoperation was necessary [44].

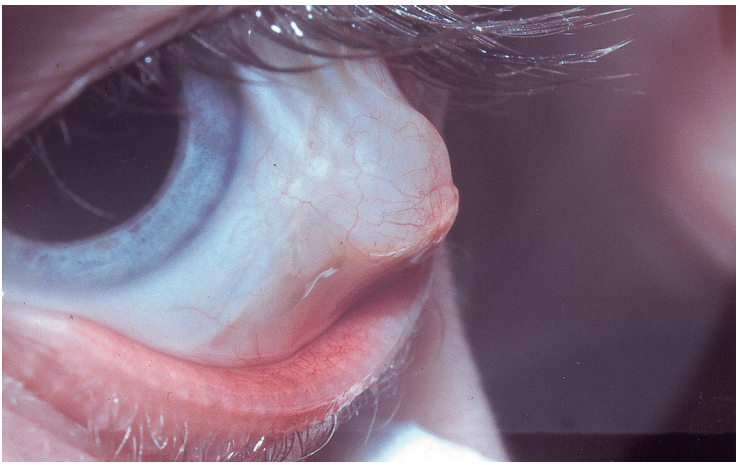


Fig. 8.**40** An eye 2 years after placement of a radial buckle. The plombe is no longer indenting, but instead appears as a bulge visible under the conjunctiva. Note that the *conjunctiva over the bulge is closed*. This is *not an infected buckle*, but a buckle held in place by 2 superficial intrascleral sutures that have dissected through. The buckle was only removed for cosmetic reasons. The retina remained attached.

- **The common factor in most of these procedures is that a longer operating time is required, with longer exposure of the operative field.**
- **As a prophylactic measure, we now therefore give the patient systemic antibiotics the evening before surgery and during surgery when an eye has to undergo reoperation.**

This is to avoid the threat of infection, and we believe that, in these selected patients, systemic antibiotics are justified. In the few of such patients we have treated so far, no infections or buckle extrusions have been observed.

? What should be done at a later date if the sponge becomes visible as a bulging prominence under the conjunctiva, when the *conjunctiva itself is closed* and not irritated (Fig. 8.40)? Does this imply an infection?

▶ No.

However, it does imply that the intrascleral sutures have been placed too superficially, or that the bites of the suture were too short, tearing out through the sclera when tied under tension over the elastic buckle. If this bulge disturbs the patient, the buckle can be removed, but only for cosmetic reasons. It should be checked again beforehand, however, that the break (having been treated) has been sealed off sufficiently.

In addition, one should bear in mind the following axioms when planning a reoperation or even when treating "easy" detachments:

- There is no such thing as minor surgery; there are only minor surgeons.

- There is no such thing as surgery without complications.

These may be unexpectedly critical-sounding statements, but 30 years of experience in surgery have proved their value. The reader might wish to recall these 2 principles when assessing the indications for surgery (hopefully never marginal ones) in his or her patients.

8.15 Anatomical Results and Reasons for Failure

8.15.1 Introduction

We have concentrated here on how to reattach the retina using a minimal extraocular approach—i.e., using segmental buckling without drainage, cerclage, or additional vitrectomy. What are the results of treatment using this approach?

- **The questions that arise are:**
  1. Does this minimal extraocular surgery result in more frequent reoperations?
  2. Does the rate of redetachments increase due to the absence of a prophylactic cerclage?

Two clinical studies were undertaken to answer these questions [29, 30].

8.15.2 First Clinical Study

In the 1st study [29], 1 000 consecutive retinal detachments were treated between 1970 and 1977 with cryosurgery, segmental buckling (Lincoff sponge I) and without drainage. As may be recalled (see Chapter 8.6, p. 144), the use of nondrainage procedures increased from 80% in the first 100 patients to 99% after more experience was gained, with an average of 93% in all of the 1 000 detachments.

▶ Patients

The characteristics of the detachments treated included: 18% of the eyes were aphakic, 5% had a perforating injury, 5% had blunt trauma, 5% involved oral disinsertion, and 1.2% represented giant tears.

▶ Operation

Surgery consisted of transscleral cryopexy at a medium level (see Chapter 7, p. 93), segmental buckles in 96%, and cerclage was still used in 4%.

? Why was cerclage still used in 4%?

- Due to initially persistent uncertainties about the use of segmental buckling
- Due to our interpretation "it must be circular traction."

The change from cerclage to segmental buckling evolved over several years. In the first 100 detachments, a cerclage was still applied in 9%, but subsequently—as greater confidence in the minimal procedure was gained—it was indicated less and less often, ultimately dropping to 0% in the last 200 detachments. The segmental buckles used consisted of: Radials in 55% (53% sponges and 2% scleral pouches); radials combined with circumferentials in 13%; and segmental circumferentials in 28% (Fig. 8.**41**).

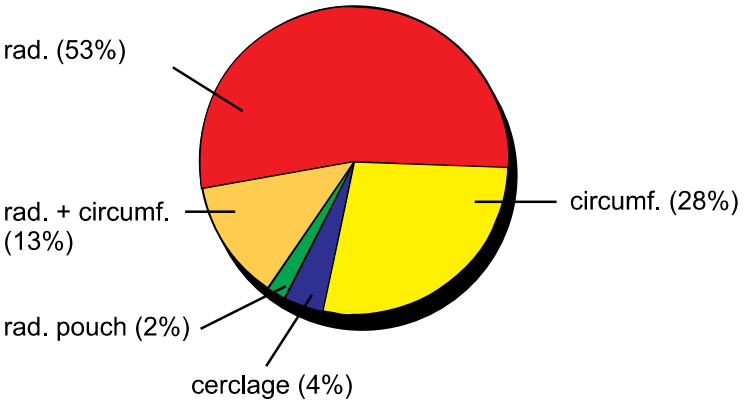


Fig. 8.**41** Minimal extraocular surgery. The pie chart shows the proportion of buckle orientation types used in 1 000 detachments undergoing surgery between 1970 and 1977. Segmental buckles were used in 96%, and cerclage was still employed in 4%.

- We had to learn step by step how to reduce our prospective and extensive surgery to segmental buckles limited to the area of the break.
- We also had to realize that **the more the detachments were studied preoperatively, the fewer uncertainties there were during the operation, and the more we were able to reduce the extent of the buckles.**

During this process of reducing the extent of the buckles, nondrainage in fact served as a sort of instant assessment of the quality of surgery.

- **This meant that if the retina was reattached after nondrainage the day after:**
  - We knew for certain that we had found all of the breaks
  - We also knew for certain that the breaks had been adequately buckled.

▶ Results and reasons for failure

The retina was reattached in 83% of detachments after a single operation. The reasons for primary failure in the remaining 17% are listed in Table 8.**4**.

? What type of procedure would you select for re-operation in these patients? At least a larger operation?

▶ No.

? Is a cerclage or vitrectomy now justified?

▶ No.

Instead, since your chances will be **8 in 10,** recalling earlier reports [46]:

- **One should search for the missing break to be buckled**
- **Or one might have to correct an insufficient tamponade.**

Both of these procedures can again imply a minimal extraocular approach.

? Is repeating the minimal extraocular approach justified in a reoperation?

▶ Let me explain this to you.

Table 8.**4** Reasons for primary failure (17%) after minimal extraocular surgery for retinal detachment (1st clinical study; n = 1 000 detachments).

Cause	%
Another hole	4.7
Inadequate buckle	2.7
PVR	6.3
Giant tear or perforating injury	2.3
No hole	1.0

PVR: proliferative vitreoretinopathy

Table 8.**5** Reasons for final failure (9%) after minimal extraocular surgery for retinal detachment (1st clinical study; n = 1 000 detachments).

Cause	%
PVR	5.6
No hole	1.0
Giant tear or perforating injury	1.2
Other reasons	1.2

PVR: proliferative vitreoretinopathy

The 1st clinical study showed that the use of the minimal extraocular approach led to success in the first 2 categories of primary failures listed at the top of Table 8.**4.** Both of these can be corrected using a rational and minimal approach, i.e., by buckling the missed break or re-buckling a break without drainage. Neither a cerclage nor vitrectomy are needed at this point.

However, in the remaining categories of primary failure, segmental buckling was only occasionally successful. After 1 reoperation without vitrectomy, reattachment was therefore achieved in 91%. The follow-up period in this series ranged from 4 months to 7½ years (mean 32 months). The reasons for final failure (9%) in this first series are given in Table 8.**5**.

In spite of the favorable results with this minimal extraocular approach at the end of the 1970s, discussion concerning the necessity of a "prophylactic" or prospective cerclage continued.

? Why?

▶ Because the use of a cerclage would at least prevent a later redetachment, i.e., later than the follow-up period of 32 months so far available.

? What should one do when proof is needed that less extensive surgery is also sufficient when more extensive surgery seems to be the established method?

▶ One has to try harder, continue to carry out less extensive surgery, and provide substantial proof—i.e., longer-term anatomical and functional results.

And this is exactly what we did.

8.15.3 Second Clinical Study

As we were convinced that this minimal extraocular procedure was a rational and valid approach, a 2nd clinical study was started in 1979, this time on a prospective basis and with a follow-up period of 15 years [30,3].

This prospective study was intended to provide answers to the open questions that remained:

1. Does cryopexy induce proliferative vitreoretinopathy (PVR)?
2. During a longer-term follow-up period of 15 years, does the rate of redetachment increase in the absence of a "prophylactic" cerclage?
3. Does the postoperative vision deteriorate in comparison to the fellow eye during a 15-year follow-up period?

▶ Patients

Between August 1979 and January 1980, 107 primary rhegmatogenous detachments were treated with segmental buckling and without drainage. Forty-six eyes had a total or 3-quadrant detachment, 43 had multiple breaks, 21 were aphakic, 1 was pseudophakic, and 16 eyes had preoperative PVR grade C1 or C2 (Table 8.**6**). Eyes with perforating injuries or giant tears were excluded from this series. This cohort of patients represented a mixture of easier as well as more complex detachments typically seen in a retinal detachment practice. Thirty-five patients died between 6 months and 15 years postoperatively, but the condition of their retinas at death was known. The follow-up period for the remaining 72 patients is 15 years.

▶ Operation

The operation was the same as in the 1st study—cryosurgery under ophthalmoscopic control to the edges of the break or breaks, and use of a sponge (Lincoff sponge **II**) or a temporary balloon (Lincoff-Kreissig balloon) to buckle the break. The size of the sponge was limited to the area of the break (Fig. 8.**42**): 76 eyes had radially oriented plombes (7 of them were a balloon, just introduced in

Table 8.6 Preoperative characteristics in 107 retinal detachments.

Characteristics	n
Detachment	
1–2 quadrants	61
3–4 quadrants	46
Break	
Horseshoe	91 (85%)
Round/oval	12
Oral disinsertion	4
Multiple (2–5)	43
Aphakia	21
Pseudophakia	1
Vitreous hemorrhage	17
PVR	
Grade B	5
Grade C1	12
Grade C2	4

PVR: proliferative vitreoretinopathy

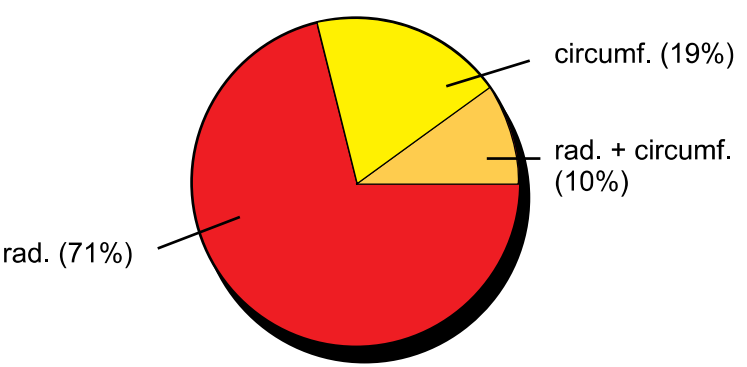


Fig. 8.42 Minimal extraocular surgery. The pie chart shows the proportion of buckle orientation types used in 107 detachments undergoing surgery between August 1979 and January 1980. The segmental buckles consisted of radials in 71% and of circumferentials in 19%; *cerclage or primary vitrectomy were not employed.*

Table 8.**7** Reasons for primary failure (7.5%) after minimal extraocular surgery for retinal detachment (2nd clinical study; n = 107 detachments).

Cause	n	
Inadequate buckle	4	(3.7%)
Another hole	2	(1.9%)
No hole	2	(1.9%)

1979), 20 circumferentials, and 11 eyes both radials and circumferentials. Subretinal fluid was not drained, and neither cerclage nor primary vitrectomy was used.
Some of the patients treated have already been discussed in the sections on nondrainage and tamponade for multiple breaks above (see Chapter 8.6, p. 144 and Chapter 8.7, p. 163).

▶ Anatomical results and reasons for failure

The retina was reattached with a single operation in 99 eyes (92.5%). The reasons for primary failure in the remaining 7.5% are listed in Table 8.**7.** As can be seen, the reasons for primary failure were related to the break to be buckled. Five patients among the 8 instances of primary failure underwent reoperation, and in all of them the retina was reattached using a second segmental sponge (3 eyes), a balloon (1 eye), or an air injection (1 eye)—again without the use of a cerclage or vitrectomy. Thus, with a single reoperation confined to the original break to be treated, retinal reattachment was achieved in 104 eyes (97%). These were the results 2 months after surgery.

The 2nd question addressed by the prospective study was whether, during a long-term follow-up period of 15 years, the rate of postoperative redetachments increases in the absence of a "prophylactic" cerclage or (as might also be asked at the end of the 1990s) without a primary vitrectomy. The raw data show that after primary reattachment during the period between 2 months and 15 years after surgery, redetachment occurred in 13 eyes (12.1%), and a reoperation was performed in a total of 10 eyes (9.3%) during that long-term period.

Table 8.**8** Incidence of *early* and *late redetachment* in 104 reattached retinas during the long-term follow-up.

	Early (2–6 months)	Late (>6 months–15 years)
Redetachment	6 (5.6%)	7 (6.5%)
Reoperation	4	6
Reattachment	2	6
Total reattachment	100 (93.5%)	99 (92.5%)

? **Does this threat of a subsequent redetachment remain the same at any point during this long postoperative course, or is it possible to restrict the potential for a redetachment to a specific period of time?**

▶ In order to assign the risk of redetachment to a specific period of time, the entire postoperative course was divided into 2 periods:
- **"Early" redetachment (2–6 months postoperatively)**
- **"Late" redetachment (6 months–15 years postoperatively)**

Early redetachment (5.6%)
Between 2 months and 6 months after surgery, early redetachment occurred in 6 eyes (5.6%). This was due to **PVR** in 4 eyes (2 of which had PVR grade C1 preoperatively), and was caused by a new break in 2 eyes. Four of these 6 eyes underwent reoperation. The 2 reattached retinas were the result of a sponge buckle (Table 8.**8**).

● 6 months after surgery, there was complete retinal reattachment in 100 eyes (93.5%).

Late redetachment (6.5%)
Between 6 months and 15 years postoperatively, late redetachment was observed in 7 eyes (6.5%). However, in contrast to early re-

Table 8.9 Reasons for final failure (7.5%) after minimal extraocular surgery for retinal detachment (2nd clinical study; n = 107 detachments).

Cause	n
PVR	4 (3.7%)
No hole found	3 (2.8%)
Massive choroidals (high myope)	1 (1.0%)

detachment, the late detachment was caused by **new retinal breaks** in all of these instances.

? What was the location of the new breaks causing late redetachment?
Does one need to look for them in the entire periphery, or are there areas of predisposition?

- The new breaks were localized within 1 quadrant of a previously treated break.
- Even with reoperation, a cerclage would not have been needed.

Six of the 7 late redetachments underwent reoperation and were reattached, 3 times with a temporary balloon buckle and 3 times with silicone explants. During the long-term follow-up, there was final reattachment of the retina in 99 eyes (92.5%). The reasons for final failure (7.5%) in this 2nd series are listed in Table 8.**9.**

PVR was in the range of 3.7% in the 2nd series, a rate slightly lower than the 5.6% seen in the 1st series (n = 1 000 detachments). Our group's surgical techniques may have become more atraumatic over time, resulting in a slightly lower rate of PVR. However, postoperative PVR still represents a major threat of redetachment during the initial months after surgery.

More specifically, redetachment occurred postoperatively at a rate of
1% per month in the first 6 months and
< 0.5% per year between 6 months and 15 years
after minimal extraocular surgery for retinal detachment.

We can now sum up the answers derived from the study to the first 2 questions addressed above:

1. The rate of PVR was 3.7%, which is relatively low.
2. During a longer-term follow-up period of 15 years, the rate of redetachment did not increase in the absence of a "prophylactic" cerclage.

These long-term results provide no support for the use of a prospective cerclage in the prevention of late redetachment. The rate of redetachment was even lower than that in a comparable series by Toernquist and Toernquist [47], in which a cerclage was used.

8.15.4 Summary

Minimal extraocular surgery using segmental sponges or a temporary balloon in combination with cryopexy and without drainage of subretinal fluid provides favorable early and long-term results. The low rate of reoperation, at less than 1% per year during a period of 15 years postoperatively, also provides support for the following practices:

- Meticulous preoperative searching for the retinal break or breaks.
- Precise localization and tamponade of the detached break or breaks at the operating table.
- Atraumatic surgical technique with low morbidity, resulting in a low rate of secondary PVR and subsequent redetachment.

During the follow-up period of 15 years, only 1 of the total of 107 eyes needed 2 reoperations.

It should be borne in mind, however, that the results of retinal detachment surgery are only proportional to what one has invested, i.e., what one has worked for.

Only after:

- A **maximum of preoperative retinal study** can surgery be reduced to
- A **minimal approach** while still ensuring
- A **maximum of retinal reattachment** with favorable long-term visual results.

- **And this is what it's all about:**
  - **The secret of success in spite of operating less.**

A valuable piece of insider advice on how to evaluate your own surgery is:

- **If you encounter a substantially higher rate of re-detachments and reoperations, don't just say: "That was a difficult detachment."**
  - Instead, consider whether you yourself might have been the reason for failure.

? **This means asking yourself:**

1. **Did I study this particular retina well enough prior to surgery?**
2. **Did I document the findings well enough by making a precise drawing to ensure detecting the break or breaks at surgery?**
3. **In addition, did I also examine the fellow eye preoperatively?**

? **Why?**

▶ The fellow eye is important because it can provide additional clues to help solve the problem of the detached retina.

To be even more specific:

- **A high rate of reoperations is a sure sign that you need:**
  - **To increase the amount of preoperative retinal study or**
  - **To improve the design of your buckling,** i.e., the orientation or combination of buckles.

You may therefore find it helpful to re-study the previous sections on how to select an optimal tamponade for the break or breaks (see Chapter 8.5, p. 138 and Chapter 8.7, p. 163).

8.16 Functional Results

8.16.1 Background

Now that we know the retina will remain attached during the long-term follow-up (with a redetachment rate of less than 1% per year after 6 months postoperatively), we can move on to the 3rd question posed above:

? Does postoperative visual function in the eyes treated using minimal extraocular surgery deteriorate in comparison to the fellow eyes during a 15-year follow-up period?

Ophthalmologists are fortunate in having the fellow eye available to check the quality of surgery with regard to early and late secondary complications, as well as secondary deterioration of visual function. As will be recalled (see Chapter 8.12, p. 204),

"Reattachment is one thing
visual function is another."

- **The only things that matter for the patient, no matter how beautifully the retina has been reattached, are:**
  - The amount of visual acuity regained
  - Being able to expect this visual acuity both **today** and **in the future**, without additional operations being needed in comparison to the fellow eye.

It should be remembered here that patients' life expectancy may be a further 20 or 30 years.

However, postoperative visual function is a complex entity, depending not only on the patient's age, but also on the preoperative state of the macula—whether it is partially detached or completely detached—the duration of macular detachment, the degree of myopia, and the amount of surgical trauma needed for repair; quite apart from the early and late secondary complications that may be induced by surgery, which can subsequently jeopardize regained visual function.

? Which of these factors can be influenced or reduced by the surgeon?

In addition to:
- Declaring macular detachment to be an emergency

The following 2 factors can also be influenced:
- Surgical trauma can be reduced by limiting it to the area of the break and keeping the surgery extraocular whenever possible.
- Postoperative complications can be reduced by avoiding procedures associated with serious secondary complications, i.e., avoiding a cerclage, silicone oil fill, and marginal indications for vitrectomy.

8.16.2 Clinical Study

However, at this point it was still an open question whether, despite the use of minimal surgery with segmental buckling, secondary deterioration of regained visual function will still occur.

Patients and Methods

Postoperative visual acuity in the 107 eyes treated with cryopexy and segmental buckling (see Chapter 8.15, p. 231) was therefore compared with the visual acuity of the fellow eyes over a period of 15 years.

The preoperative state of the macula in these 107 detachments was assigned to 3 groups (Table 8.**10**, Fig. 8.**43**). If the macula was attached, the eye was designated as group I (n = 46); if it was partially detached, group II (n = 10); and if it was completely detached, it was classed as group III (n = 51). Visual acuity was tested using the Snellen chart. The mean preoperative visual acuity of the eyes with a detachment was 20/30 in group I, 20/100 in group II, and 20/400 in group III; it was 20/25 in the fellow eyes.

Visual Function

The mean preoperative visual acuity in all of the 107 eyes with detachment was 20/60 and improved postoperatively to 20/40

Table 8.**10** Preoperative state of the macula in 107 eyes with retinal detachment, classified into 3 groups.

Group	n	Mean age (years)	Mean visual acuity
Group I (macula attached)	46	51	20/30
Group II (macula partially detached)	10	48	20/100
Group III (macula detached)	51	60	20/400

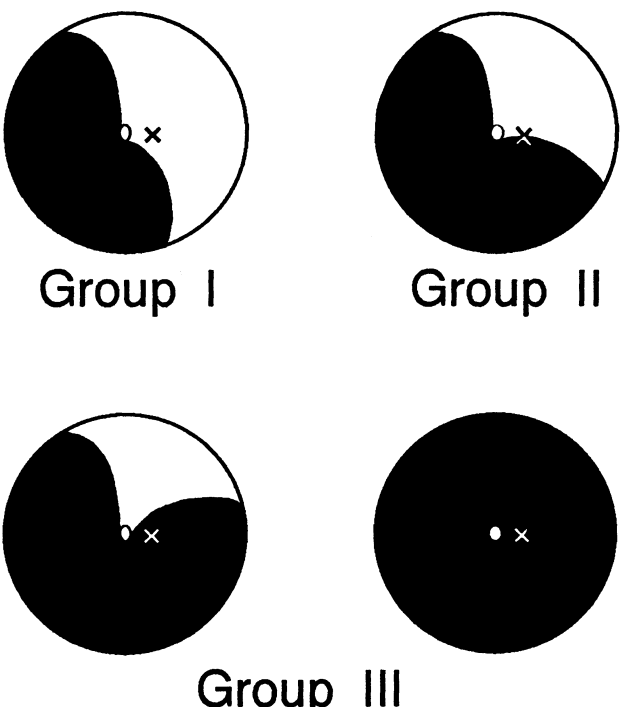


Fig. 8.**43** Preoperative macular involvement in 107 retinal detachments. In group I, the macula was attached (n = 46); in group II, it was partially detached (n = 10); and in group III (n = 51), it was completely detached.

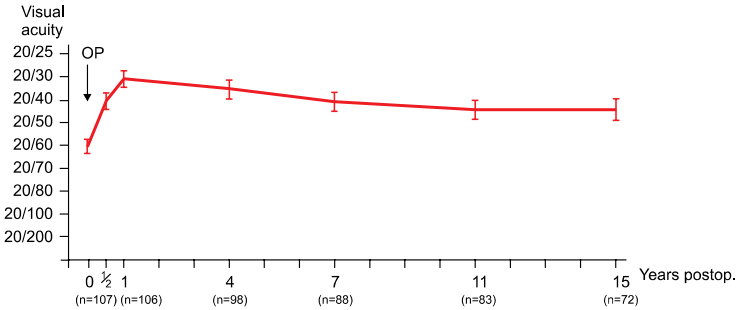


Fig. 8.**44** A 15-year follow-up of mean visual acuity in 107 patients with retinal detachment treated with minimal extraocular surgery (segmental buckling without drainage). Seventy-two patients were alive 15 years after operation. The number of patients represented is indicated at each data point. The vertical bars represent standard error.

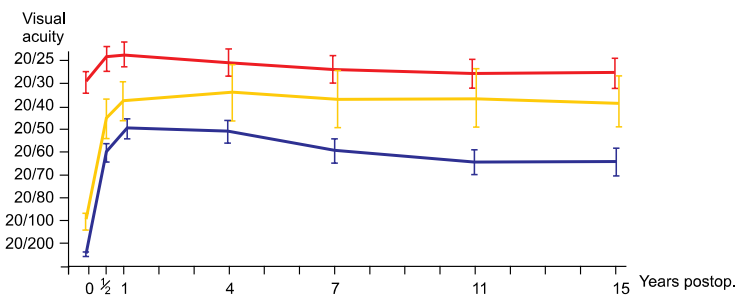


Fig. 8.**45** A 15-year follow-up of mean visual acuity in the same 107 patients as in Figure 8.**44,** but divided into 3 groups according to the preoperative state of macular involvement: Group I (macula attached, n = 46) is represented by the red line, group II (macula partially detached, n = 10) by the yellow line, and group III (macula completely detached, n = 51) by the blue line. The vertical bars represent standard error.

during the first 6 months, reaching a maximum of 20/30 at 1 year (Fig. 8.**44**). Figure 8.**45** shows the visual acuity in the 3 different groups, defined according to their preoperative macular state and plotted separately relative to the time after surgery. As can be seen, visual acuity in group I, the patients with a preoperatively attached

macula, was better at all time points than in patients with a partially or completely detached macula; this was to be expected.

There was a statistically significant improvement in visual acuity in group II ($P = 0.002$) and group III ($P < 0.001$) between the operation and 6 months postoperatively. The slight improvement in visual acuity apparent in group I was due to the clearing of a vitreous hemorrhage.

Surprisingly, there was a slight linear decrease in all 3 groups after 1 year. The changes per interval were significant in group I ($P = 0.007$) and group III ($P < 0.001$). The decrease was greater in group III; this was the group with most of the patients over 60 years, and the decrease seen in this group was age-related, among other reasons.

? Which group of operated eyes is capable of demonstrating whether or not placing a segmental buckle will jeopardize early and late visual function?

▶ All that is necessary is to compare the visual function in the operated eyes in which the macula was attached preoperatively with that in the fellow eyes during a long-term follow-up.

In Figure 8.**46,** visual acuity in the fellow eyes and operated eyes of patients with a **preoperatively attached macula** is plotted at 1 year and 4, 7, 11, and 15 years after surgery. If the presence of a segmental buckle was capable of jeopardizing visual function, it would have become evident during this long-term follow-up. And it did not happen.

- **— The slight decrease in visual acuity observed over this 15-year period was present in both eyes.**
- **— There was no statistically significant difference between the operated (the 46 eyes with macula attached preoperatively) and the unoperated fellow eyes at any time interval.**

When analyzing visual function in all of the 107 patients over time to see whether there is a similar development, it should

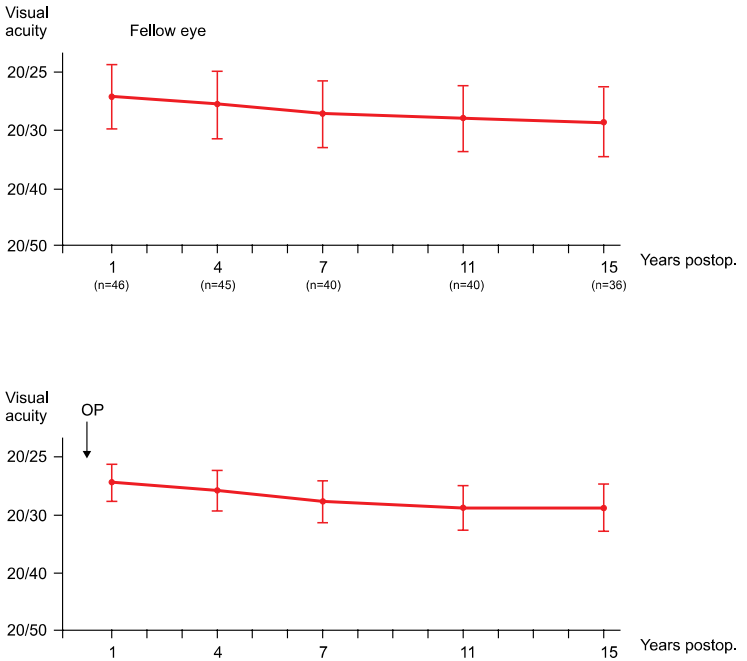


Fig. 8.**46** Unoperated fellow eyes (**top**) and operated eyes (**bottom**) during the long-term follow-up: Mean visual acuity in **patients with a preoperatively attached macula** (group I, n = 46), 1–15 years after treatment with minimal extraocular surgery (segmental buckling without drainage). The number of patients alive fell from 46 to 36 during the study period. The vertical bars represent standard error. *During the study period of 15 years, the difference in the decrease of visual acuity in the 2 groups was not significant at any interval.*

first be borne in mind that all of the patients aged a further 15 years during the period of study. Some data from Slataper may help to elucidate the problem of aging and decrease of visual function [48].

Slataper plotted the visual acuity in 17 349 eyes of normal individuals as a function of age (Fig. 8.**47**).

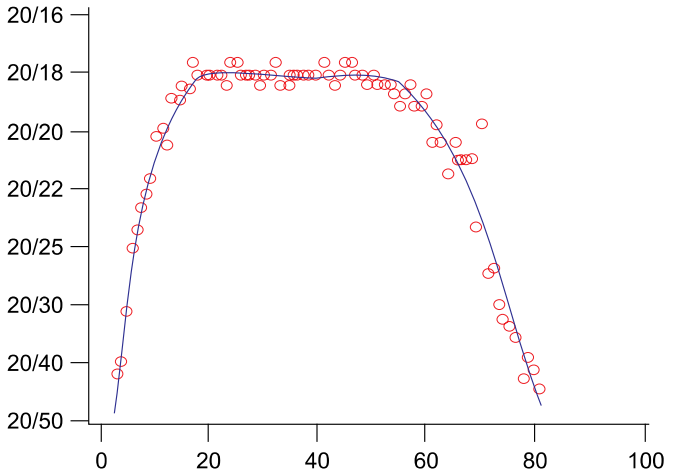


Fig. 8.**47** Visual acuity as a function of age in 17 349 individuals, replotted from the cross-sectional study by Slataper [48]. After the age of 60 years, there is a continuous decrease in visual acuity (0.07 line per year in the Snellen chart).

- **The curve shows 3 phases:**
  - Increase of visual acuity in childhood
  - Stability during middle age
  - Decrease beginning at the age of 60.

Most of the patients in our own study were older than 60 years prior to surgery. The declining part of Slataper's curve corresponds precisely to the decrease in visual acuity observed in our **107 patients, both in the fellow eyes and the eyes in which surgery** was carried out. In the Snellen chart, this decrease occurs at a level of 0.07 line per year (Fig. 8.**48**). The mean visual acuity of the fellow eyes was 20/25 after 1 year and 20/30 after 15 years; and in the operated eyes the figure was 20/30 at 1 year and 20/40 after 15 years.

- **There was no statistically significant difference in the postoperative decrease at any time between the 2 curves for all of the operated eyes with a detachment and the fellow eyes.**

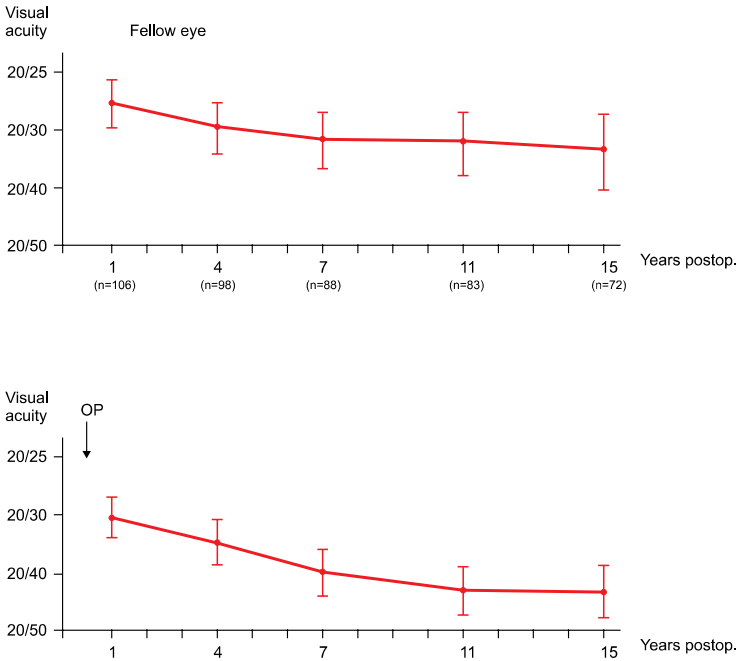


Fig. 8.**48** Unoperated fellow eyes (**top**) and operated eyes (**bottom**) during the long-term follow-up: Mean visual acuity in **106 patients with retinal detachment**, 1–15 years after treatment with minimal extraocular surgery, i.e., segmental buckling without drainage (1 patient died during the first year after surgery). The number of patients alive fell to 72 after 15 years. The vertical bars represent standard error.
During the study period of 15 years, the difference in the decrease of visual acuity in the 2 groups was not significant at any interval.

These data thus supply the answer to the third question:

3. Minimal extraocular surgery consisting of cryopexy and segmental buckling to tamponade the retinal break or breaks, does not have a negative effect on postoperative vision, which does not deteriorate in comparison to the fellow eye during a 15-year follow-up period.

8.17 Conclusion

Minimal extraocular surgery consists of cryosurgery and segmental buckling to tamponade the break or breaks without drainage. In the treatment of retinal detachment, this procedure is feasible in more than 90% of patients; the retina is reattached in over 90% of detachments, and remains attached over a period of up to 15 years. The rate of redetachment requiring reoperation is less than 1% per year during the long-term follow-up.

- Since surgery is minimal, the resulting complications are minimal, and long-term visual function is consequently not jeopardized due to secondary complications in comparison to the fellow eye.

These long-term results with minimal surgery support our philosophy:

- Less surgery to start with means better sight at the end. There is a better prognosis for the operated eye and its long-term visual function.

- Another of our principles of treatment is:
  - To reattach a retina,
    2 small operations are better than 1 large one.

These 2 statements may be difficult to accept, but in the meantime strong evidence has accumulated that a larger operation (particularly involving a cerclage) can reduce retinal and choroidal blood flow. These findings were reported in the early 1980s by Dobbie [8], Diddie and Ernest [9], Yoshida et al [10], and later confirmed by Scheider and Korabjelnikoff [11].

The long-term visual results after segmental buckling are a challenge to those who still practice cerclage in eyes with detachments to review their data and compare the long-term functional results of cerclage-operated eyes with vision in the fellow eye in a long-term follow-up study. The same applies to those who treat detachments using primary vitrectomy.

After any type of eye surgery, only the long-term visual results in comparison to the unoperated fellow eye can answer as yet unresolved questions, such as:

? **Will this special procedure jeopardize regained visual function in comparison to the fellow eye during a follow-up period of several years?**

? **Will this alternative procedure compare favorably to the 15-year functional results already available after minimal extraocular surgery (segmental buckling without drainage)?**

The minimal extraocular surgery described here has provided evidence that an eye with a segmental buckle in place does not lose more sight than the unoperated fellow eye during a period of 15 years after surgery. It is a procedure with low morbidity, and long-term data concerning visual function are so far only available for this operation.

- Prior to surgery, patients should not only receive **information about the anatomical results, but also about the visual function to be expected in the early postoperative period and in specifics the subsequent years.**
- Patients should be **also informed** that comparable long-term visual results after alternative procedures are not yet available.

8.18 Retinal Detachments with Proliferative Vitreoretinopathy Grades B, C1, and C2

8.18.1 Classification of Proliferative Vitreoretinopathy

Proliferative vitreoretinopathy (PVR) is the major cause of final failure in the treatment of retinal detachment (Fig. 8.**49**). It is characterized by intravitreal, epiretinal, subretinal, and intraretinal proliferations, which result in strands and membranes that contract and give rise to tractional detachment. Considerable efforts have been invested in research into ways of counteracting this serious

Fig. 8.**49** A proliferative vitreoretinopathy (PVR) detachment with a full-thickness retinal starfold.

cause of failure, including the use of various drugs or complex surgical procedures. However, a unique method of treatment has not been developed yet.

- One major difficulty that did develop, however, is that a universally valid standard classification of PVR has not been available on which to base comparisons of the results obtained with the various methods of treatment used by various researchers or clinicians.

This problem was recognized at the end of the 1970s, and in 1983 the Retina Society Terminology Committee [49] published a stand-

ard classification of proliferative vitreoretinopathy. This replaced a variety of terms then in use, such as "massive vitreous retraction," "massive preretinal retraction," and "massive periretinal proliferation." The 1983 classification subdivided PVR into 4 grades of severity; it is pragmatic and easy to use, and was therefore accepted at once and widely used during the 1980s and 1990s, forming the basis for many clinical reports.

In 1991, another, "updated" classification of PVR was published [50], which is more complex and more difficult to understand and to apply. Consequently, the older classification is still used by many surgeons even today; both classifications will be discussed here.

▶ Original classification of PVR (Table 8.11)

In the 1983 classification, PVR was divided into 4 different **grades of severity:**

A = minimal, B = moderate,
C = marked, D = massive.

As mentioned above, this classification of PVR was accepted without delay and applied in everyday clinical practice. It provided a way of evaluating different grades of PVR detachment, and made it possible for the first time to compare alternative treatments and their results.

However, after vitrectomy was integrated into the spectrum of treatment modalities, the development of anterior PVR became prominent,
and there was a need for a different classification that integrated anterior PVR and differentiated between various types of PVR.

▶ Updated classification of PVR (Table 8.12, Fig. 8.50)

The new classification was published in 1991. It contains a detailed description of **posterior and anterior PVR** contractions, which are divided into **5 types:** Focal, diffuse, subretinal, circumferential, and anterior with displacement of the retina.

The extent of PVR is more precisely defined, not merely into 1–4 quadrants, but into **1–12 clock hours.**

Table 8.**11** Original 1983 classification of proliferative vitreoretinopathy (PVR) [49].

Grade A (minimal)	Vitreous haze, vitreous pigment clumps
Grade B (moderate)	Wrinkling of the inner retinal surface, rolled edge of retinal break, retinal stiffness, vessel tortuosity
Grade C (marked)	**Full-thickness fixed retinal folds in 1–3 quadrants:**
C1	1 quadrant
C2	2 quadrants
C3	3 quadrants
Grade D (massive)	**Fixed retinal folds in 4 quadrants and 3 different configurations of funnel shape:**
D1	Wide funnel shape
D2	Narrow funnel shape
D3	Closed funnel shape (optic nerve head not visible)

Table 8.**12** Updated 1991 classification of proliferative vitreoretinopathy (PVR) [50].

Grade A	Vitreous haze, vitreous pigment clumps	
Grade B	Wrinkling of the inner retinal surface, rolled edge of retinal break, retinal stiffness, vessel tortuosity	
Grade C		
Location	PVR contractions are divided into:	
CA	**Anterior** contractions	
CP	**Posterior** contractions	
Extent	Extent of PVR contractions is denoted in numbers of **clock hours**, ranging from 1–12:	
CA1–12	Anterior contractions of 1–12 clock hours	
CP1–12	Posterior contractions of 1–12 clock hours	
Type	PVR contractions are divided into **5 types:**	
Type 1	Focal contraction (starfold)	X
Type 2	Diffuse contraction (group of starfolds)	X X X
Type 3	Subretinal proliferation	— —
Type 4	Circumferential contraction	xxxx ↑ ↑
Type 5	Anterior displacement by contraction	xxxx

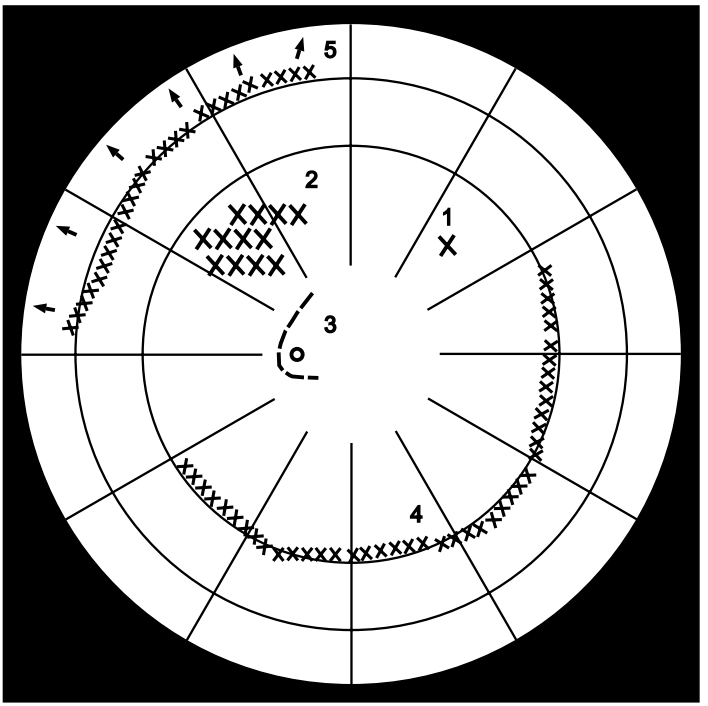


Fig. 8.**50** Retinal diagram depicting the various types of full-thickness retinal folding, as published by Machemer et al [50].

Type 1	Focal contraction (starfold)	X
Type 2	Diffuse contraction (group of starfolds)	X X X
Type 3	Subretinal proliferation	— — —
Type 4	Circumferential contraction	xxxx ↑ ↑
Type 5	Anterior displacement by contraction	xxxx

? How would you proceed when documenting the PVR in a detachment using the updated and more specific PVR classification of 1991?

In this new classification, grades A and B of PVR are the same as in the older classification, but grade C has been entirely altered and enlarged. Grade D has been eliminated.

In summary, in the 1983 classification the PVR contractions are measured by the number of quadrants in which they are found. There is no distinction between anterior and posterior PVR. However, the updated PVR classification distinguishes between anterior and posterior location of PVR. It no longer denotes the extent of PVR in quadrants, but in clock hours, and the proliferation itself is classified into 5 different types of manifestation.

This new classification of PVR is very suitable for the use in research projects and randomized clinical studies, since it provides more specific documentation and definition of PVR, particularly when comparing the preoperative and postoperative results obtained with different treatment modalities.

? But which classification is generally used today by clinicians?

▶ On the whole, it is still the 1983 classification that is in use, because it is less complex and easier to remember and to document.

Which classification to use is a personal decision, but it has to be one or the other. If you resort to the original classification of PVR, then you also have to differentiate between anterior proliferative vitreoretinopathy (aPVR) and posterior proliferative vitreoretinopathy (pPVR) grades C1, C2, and C3. This is because the preoperative findings and visual acuity in PVR detachments should always be compared with the postoperative results. However, if one is considering participating in a randomized study concerning various treatment modalities for retinal detachment, experience with the updated 1991 classification is needed.

8.18.2 Treatment of Retinal Detachments with PVR Grades B, C1, and C2

There is controversy concerning the treatment of retinal detachments with a moderate degree of proliferative vitreoretinopathy. In the 1960s and 1970s, the primary approach would have been a cerclage with drainage. If this did not succeed, another cerclage in a more posterior position would have followed. From the end of the 1970s and up to the 1990s, segmental buckling with or without a

cerclage developed to become the treatment of choice. However, in parallel with this, the technology of vitrectomy has been refined and its indications enlarged since the mid-1980s.

- **The controversy concerns the issues:**
  - Up to which grade of PVR should buckling first be tried?
  - What are the long-term results with minimal buckling when cerclage or vitrectomy are not added?

As will be recalled, PVR is still the most important cause of surgical failure in the treatment of rhegmatogenous retinal detachment [51]. In a series of 107 consecutive detachments treated with cryosurgery, segmental buckling and without drainage as mentioned above, postoperative PVR grade C or D, causing final failure, developed in 3.7% [30]. In another series of 500 uncomplicated detachments that were treated with cryosurgery, a temporary balloon buckle and without drainage, the rate was at 0.2% [52].

However, although the treatment of PVR detachment is still controversial, there is one issue on which everyone would agree today:

- **PVR represents a cascade of biological over-reactions. The aim of any treatment should therefore be:**
  - To intercept this biological process
  - To prevent it from progressing
  - And even more so, to encourage it to regress.

? How can the continuum of PVR be intercepted?

▶ **Use atraumatic surgery**, which should be:
- Minimal
- Extraocular

This is in order to avoid the breakdown of the blood aqueous barrier.

The risk factors for the development of postoperative PVR are:
- Vitreous hemorrhage
- Choroidal effusion
- Hypotony after drainage
- Chronic inflammation
- Intraocular gas
- Vitrectomy
- Traumatic surgery

An atraumatic and extraocular surgery, such as segmental buckling without drainage, should avoid most of the risk factors listed above.

Minimal extraocular surgery can help to avoid breakdown of the blood aqueous barrier by the following methods:
- Avoiding excessive indentation with the cryoprobe when localizing the break, or during cryopexy
- Limiting cryopexy to the area of the break
- Avoiding drainage of subretinal fluid, thus avoiding hypotony and the need for an intraocular injection to restore volume
- Avoiding the use of intraocular gas and if gas is used, a short-duration gas, such as Xenon, should be selected (Xenon has a half-life of 6 hours, and provokes only minimal infiltration of cells and protein into the vitreous).

8.18.3 Clinical Study

A prospective study was carried out to address the following questions:
1. Can minimal extraocular surgery, consisting of cryosurgery and segmental buckling for the break, without drainage of subretinal fluid, without cerclage, and without vitrectomy, reattach a retina that is complicated by PVR grades B, C1, or C2?
2. Does minimal extraocular surgery encourage regression of PVR grades B or C and result in long-term reattachment?
3. How will be the long-term visual function?

If the answers to these questions were in the affirmative, it would imply that for a PVR detachment of grade B or C, a first attempt using segmental buckling should be considered instead of a larger primary surgical intervention, such as a vitrectomy or a cerclage.

▶ Patients

A prospective study was carried out in 72 retinal detachments complicated by PVR grades B and C. The patients included were recruited from 695 consecutive patients with detachment who underwent surgery in Tuebingen between 1979 and 1982, before vitrectomy became a routine treatment for moderate PVR, and the follow-up period was 11 to 13 1/2 years.
PVR was classified according to the Retina Society Terminology then available, which specifies grades B, C, and D [49]. However, in 1979 we had already differentiated between posterior (pPVR) and anterior (aPVR) PVR findings with regard to starfolds and traction lines.

Follow-up examinations were carried out at 1 month, 2, 3, and 6 months and thereafter at 1-year intervals after surgery. The study was concluded in July 1993. For patients still alive, the follow-up ranged between 11 and 13 1/2 years. Thirty-one patients (43%) died between 6 and 143 months after surgery, so that the mean follow-up time for all operated patients was 7 1/2 years.
There were 22 detachments with PVR grade B and 50 with grade C; 38 eyes had PVR grade C1, 11 had grade C2, and 1 eye had C3 (Table 8.**13**). Preoperative characteristics of the 72 PVR detachments included: 14 patients with myopia of between –2 dpt and –10 dpt and 1 patient with –22 dpt. Aphakia was present in 15 eyes, a moderate vitreous hemorrhage in 6, and a choroidal effusion in 2. In 1 eye there was a macular pucker, and in another 1 a pseudophakia.

Preoperative extent of the detachment, state of the macula, and type of retinal tears to be treated are summarized in Table 8.**14.** A horseshoe tear was present in 48 eyes, an oval or round hole in 22, and in 2 detachments no hole could be found, despite a meticulous and repeated search for the break.

▶ Operation

The operation consisted of cryopexy and segmental buckling (n = 68 eyes) or a temporary balloon (n = 4 eyes). Diagnostic freezing of the

Table 8.13 Retinal detachments (n = 72) with preoperative proliferative vitreoretinopathy (PVR), grades B and C.

PVR grade	n
B	22
C	50
aC1	25 + 1*
pC1	12
pC2	5
a + pC2	6
pC3	1

* Preoperative macular pucker

Table 8.14 Preoperative characteristics of 72 retinal detachments with proliferative vitreoretinopathy, grades B and C.

Characteristics	n
Extent of detachment	
1–2 quadrants	21
3–4 quadrants	51
Macula	
Attached	1
Partially detached	10
Detached	61
Tears	
Horseshoe	48
Oval/round	22
No hole	2

retina and drainage of subretinal fluid were avoided. The extent of the buckle and cryopexy were limited to the area of the break.

- Whenever possible, a radial orientation of the sponge buckle (n = 40) was chosen. Multiple breaks close together were supported with a short circumferential buckle (n = 13). A radial in combination with a circumferential buckle was used in 15 eyes.
- A cerclage or a primary vitrectomy were not used in any of the 72 PVR detachments.

Table 8.**15** Reasons for primary failure in the treatment of 72 retinal detachments with proliferative vitreoretinopathy (PVR), grades B and C.

Cause	n
Another hole	4
Inadequate buckle	4
PVR	6
No hole found	1

In the 2 eyes in which a break was not found, a segmental circumferential buckle was applied to the area most likely to harbor the primary break, as defined by the Rules of how to find the primary break (see Chapter 2.2, p. 13).

▶ Results and reasons for failure

- **After 1 segmental buckle operation with cryosurgery**
  - Complete retinal reattachment occurred in 57 eyes (79%)
  - Partial reattachment in 11 (15%)

The reasons for primary failure are listed in Table 8.**15.** As might be expected, the first 2 categories are iatrogenic, and are relatively easy to repair. In 6 eyes, the 2nd operation involved a radial buckle, a balloon, a temporary catgut cerclage or a Xenon gas injection. The retina reattached in 5 eyes.

- **The results after the 2nd procedure were:**
  - Complete retinal reattachment in 62 eyes (86%)
  - Partial reattachment in 6 (8.5%)
  - Detachment in 4 (5.5%)

In the subsequent long-term study, the retinal findings were observed in 68 eyes. There were 62 eyes in which the retina completely reattached, and 6 in which it partially reattached. To assign redetachment to a specific period of time, the postoperative follow-up was divided into 2 periods:

- "Early" redetachment, 1 week to 6 months
- "Late" redetachment, 6 months to 13$^1/_2$ years.

▶ Early redetachment (8.3%)

Early redetachment occurred in 6 eyes. It was caused by a new break in 4 eyes, and by increasing PVR in 2. The 4 eyes with a new break underwent reoperation with another segmental buckling procedure. Reattachment occurred in all 4, but 1 redetached after 3 months due to increasing PVR.

- **The results 6 months postoperatively were:**
  - Complete retinal reattachment in 62 eyes (86%)
  - Partial reattachment in 3 (4%)
  - Persistent detachment in 7 (10%)

? The question that then arose was whether the reattachment in the 86% of eyes would persist during a longer follow-up period?

▶ To our surprise, no redetachments occurred between 6 months and 9 years after surgery.

These findings demonstrate that treatment with segmental buckling was sufficient in 86% of detachments with a moderate degree of PVR during this long period of time.

▶ Late redetachment (2.8%)

A late redetachment developed in 2 eyes: 1 after 9 years and 1 after 11 years. It was caused by increase of PVR in both patients.

- **After a mean of 7 1/2 years, complete reattachment had persisted in 61 eyes (85%) after:**
  Cryopexy with segmental buckling and without a cerclage or vitrectomy.
  Only 10 reoperations were required in a total of 72 PVR detachments grades B and C during the entire long-term (mean 7 1/2 years) follow-up period (Table 8.**16**).

▶ Complications

During the long-term follow-up, PVR perceptibly increased in 14 eyes. Rubeosis iridis or secondary glaucoma did not develop in

Table 8.**16** Long-term anatomical results after the 1st operation and with or without reoperation, in 72 PVR detachments, grades B and C.

State of retina	Postoperatively	
	6 months	> 6 months to 11 or 13 1/2 years*
Reattached	62 (86%)	61 (85%)
Partially reattached	3 (4%)	2 (3%)
Detached	7 (10%)	9 (12%)

* Mean 7 1/2 years (31 patients died during the long-term follow-up)

Table 8.**17** Delayed postoperative reattachment of the tractional component after segmental buckling without drainage in 34 of 61 reattached PVR detachments, grades B and C.

Preoperative grade of PVR	n	Postoperatively delayed reattachment			
		> 2 weeks to 1 month	> 1 month to 6 months	> 6 months to 18 months	5 years
B	8	2	5	1	–
C1	16	5	7	3	1
C2	10	3	5	2	–
		10	17	6	1

any of the 72 eyes. In 9 eyes with reattached retinas and in 3 of the 14 eyes with postoperative progression of PVR, a macular pucker developed between 2 and 14 months after surgery. Treatment with vitrectomy and membrane peeling was not performed, also not in the 1 eye in which a pucker was present preoperatively.

▶ Delayed absorption

As might be expected in this series of 72 detachments with PVR grades B and C treated without drainage, *delayed reattachment* of the tractional component of the detachment was observed in 34 eyes (Table 8.**17**).

In 24 eyes, the residual tractional detachment disappeared between 1 month and 5 years (see Chapter 8.13, p. 212).

● **In every instance, the residual tractional detachment had concave surfaces and concave contours, and did not invade the posterior pole.**

No attempt was made to flatten the residual detachments, and the end result was usually a line of dry starfolds (Figs. 8.**51,** 8.**52**).

Figure 8.**53** illustrates the eye of a patient with a PVR detachment who was sent to us for reoperation.

? **Which type of reoperation would you have selected?**
A vitrectomy, a cerclage, a segmental buckle, or a balloon?

▶ The eye was treated with a **temporary balloon** buckle beneath the break, anterior to the existing buckle at 9 o'clock.

The rhegmatogenous portion of the detachment was absorbed in 3 days. Over the next 6 months, the tractional component flattened, and after an additional 12 months only flat starfolds remained, which almost completely disappeared after 4 years.

▶ Functional results

? **In the end, what is the one thing that is important to the patient in this situation?**

▶ **Not how the retina will look to the surgeon, but:**
- What will visual function be like after surgery?
- What will it be like in the years to come?

The visual results obtained by segmental buckling without drainage will **include the 13 eyes with a macular pucker (1 present preoperatively,** 12 developed postoperatively) which were not treated with vitreoretinal surgery which was available at that time.

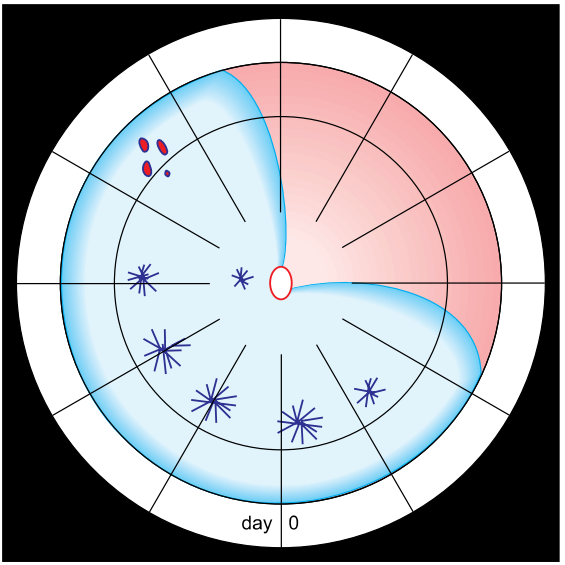


Fig. 8.**51 a** A 3-quadrant PVR detachment, grade pC2, with a group of breaks at 10:30 and a preoperative macular pucker.

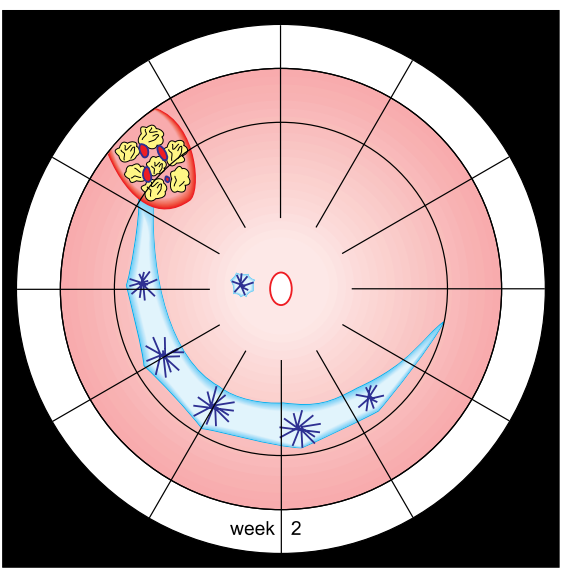


Fig. 8.**51 b** Retina 2 weeks postoperatively. Tamponade of the breaks at 10:30 with a large radial buckle without drainage resulted in retinal reattachment with a residual tractional detachment in the area of the starfolds. Note the *concave surface and concave contours of the residual tractional detachment.*

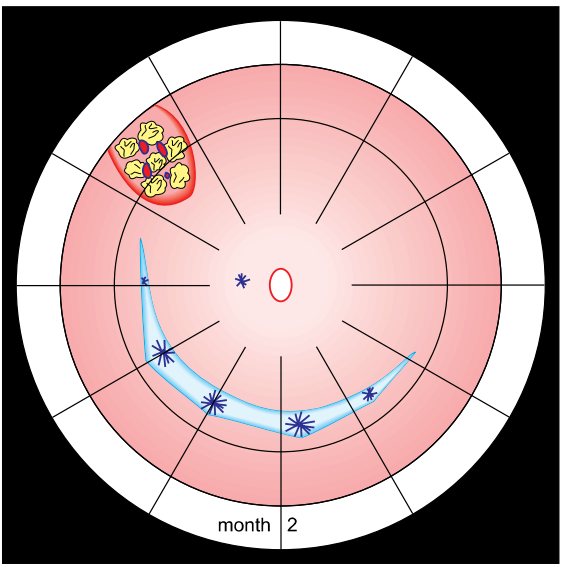


Fig. 8.**51 c** Retina 2 months postoperatively. The retina is reattached, and the residual tractional detachment in the area of starfolds has diminished.

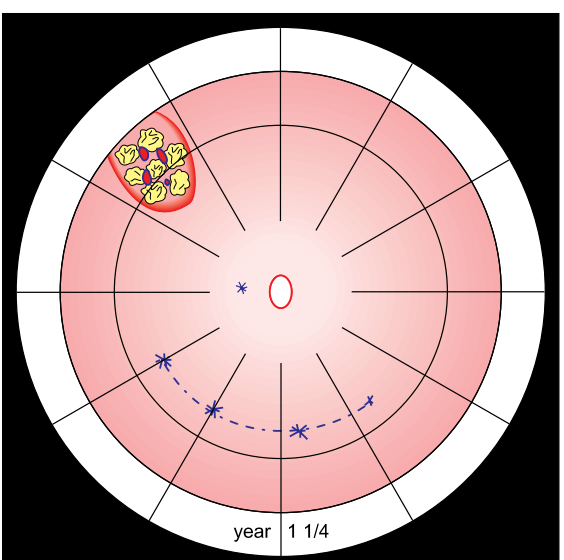


Fig. 8.**51 d** Retina 1¼ years postoperatively. There are dry starfolds as remnants of PVR grade pC2.

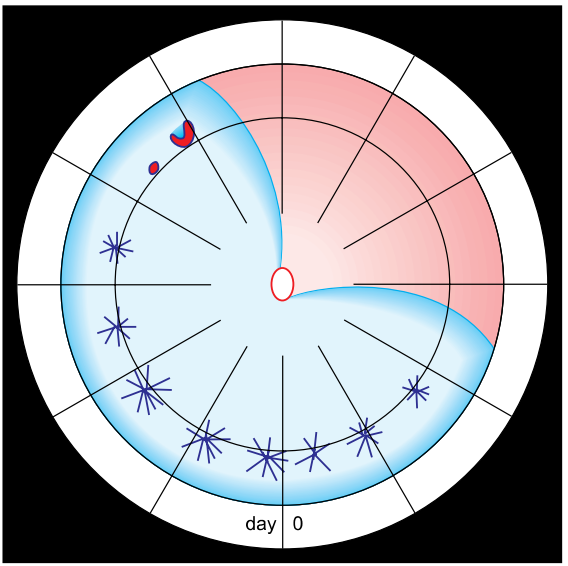


Fig. 8.**52 a** A 3-quadrant PVR detachment, grade aC2, with a round hole at 10:30 and a horseshoe tear at 11 o'clock.

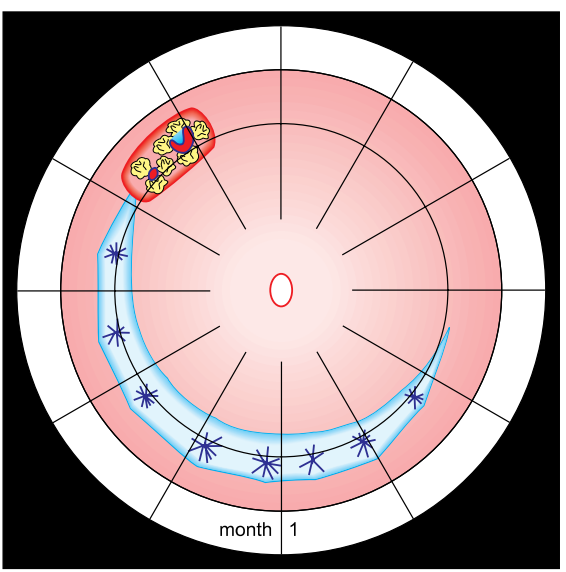


Fig. 8.**52 b** Retina 1 month postoperatively. After tamponade of the 2 breaks with a short circumferential buckle without drainage, the retina reattached except for a *concave residual tractional detachment* from 3:30 over 6 to 10 o'clock. The patient was mobilized.

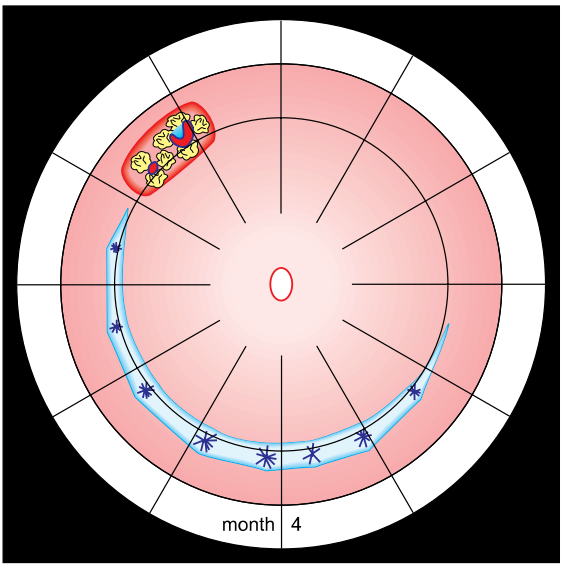


Fig. 8.**52 c** Retina 4 months postoperatively. The PVR has regressed, and the tractional detachment is now limited to the area of the starfolds.

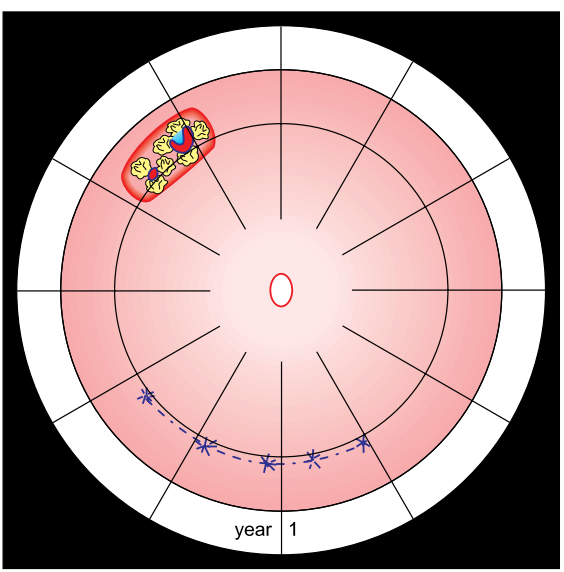


Fig. 8.**52 d** Retina 1 year postoperatively. The retina has reattached, and the residual tractional detachment has disappeared. There are only dry starfolds, barely visible, as remnants of PVR grade aC2.

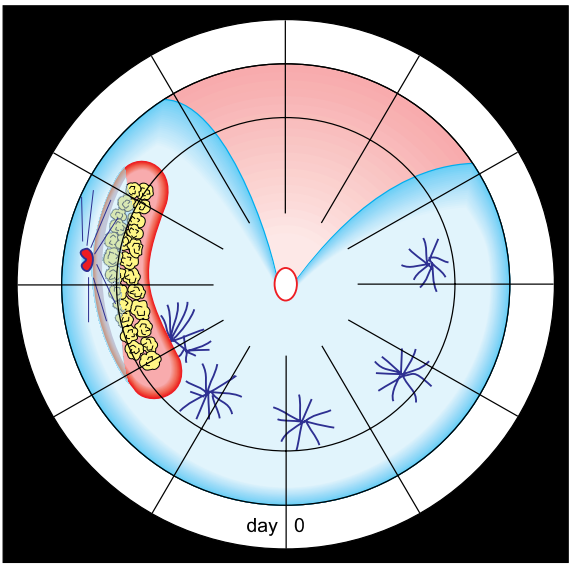


Fig. 8.**53 a** A 3-quadrant PVR detachment, grade pC2. The patient was sent for re-operation after an unsuccessful buckle operation. There was a tear anterior to the existing buckle at 9 o'clock. Note the *convex borders of the detachment.*

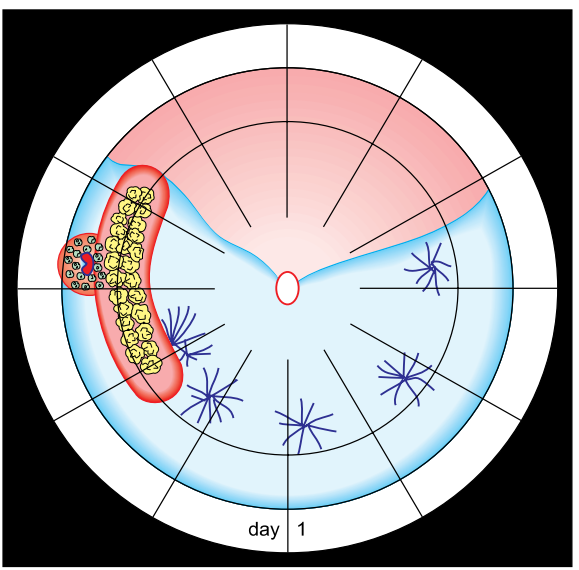


Fig. 8.**53 b** Retina 1 day after treatment. A temporary balloon without drainage was placed under the horseshoe tear at 9 o'clock under local anesthesia. By the 1st postoperative day, the tear had reattached to the balloon buckle and was surrounded by interrupted laser lesions. Extent of detachment had hardly changed, *contours had become concave.*

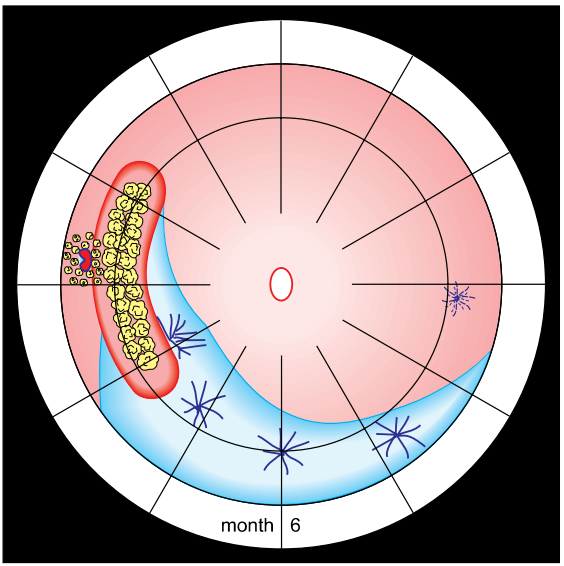


Fig. 8.**53 c** Retina 6 months after the balloon operation. *The residual tractional detachment,* which already showed this shape at 1 month after the operation, *did not change substantially* during the postoperative course up to 6 months. The macula was reattached.

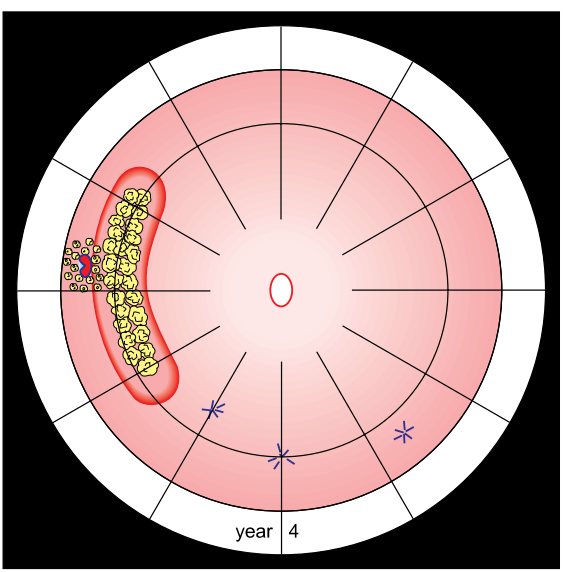


Fig. 8.**53 d** Retina 4 years after the balloon operation. *The residual tractional detachment had spontaneously disappeared entirely.* There are only remnants of starfolds faintly visible. The retina remained attached for an additional 5 years.

Figure 8.**54** shows the functional results 6 months after surgery in form of a scattergram, including the 8 failures among the 72 detachments treated with segmental buckling. The symbols above the diagonal indicate improvement in visual acuity, and those below show diminished acuity. At 6 months, there was diminished vision in 10 eyes, the 12 lying on the diagonal were unchanged, and improved vision was observed in 50 eyes, 26 of which had a visual acuity between 20/25 and 20/60.

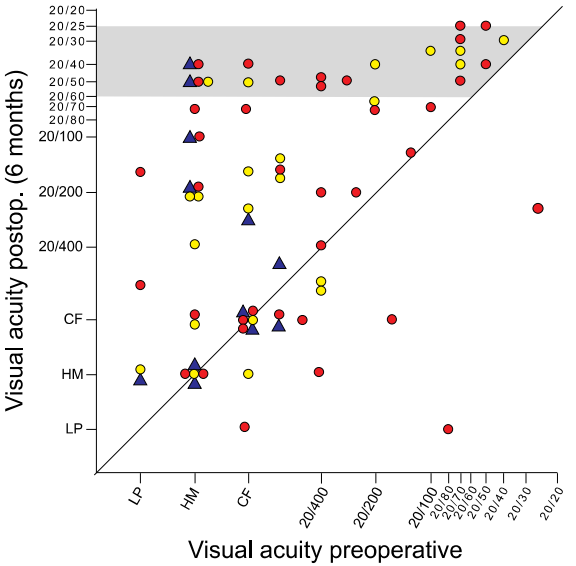
● *This implies that 26 patients (36%), with a PVR detachment grades B, C1 or C2, or every 3rd patient, had regained reading vision or more.*

In the instances in which visual acuity decreased postoperatively, this was either due to failure to reattach the retina or to a macular pucker that developed postoperatively and which was not removed by vitreoretinal surgery.

? How do the long-term functional results compare?

▶ There was no difference between the visual acuity at 6 months and the acuity at a mean of $7^1/_2$ years after surgery, and this was statistically significant.

Fig. 8.**54** Visual acuity in 72 patients with PVR detachments, grades B and C (operated and reoperated with segmental buckling and without drainage, without cerclage or vitrectomy) after *6 months* (**top**) and after a *mean of* $7^1/_2$ *years* (**bottom**). The 13 eyes with macular pucker that did not undergo vitrectomy (1 present preoperatively, 12 postoperatively) are included. In this scattergram, the symbols lying on the diagonal represent patients in whom the preoperative and postoperative visual acuity was unchanged; the symbols above the diagonal represent those in whom postoperative visual acuity improved in comparison to the preoperative status. Shaded area defines the range of visual acuity between 20/25 and 20/60. Yellow: PVR grade B; red: PVR grade C1; blue: PVR grades C2 or C3. CF: Counting fingers, HM: Hand movements., LP: Light perception. ▷


Visual acuity postop. (6 months)
20/20
20/25
20/30
20/40
20/50
20/60
20/70
20/80
20/100
20/200
20/400
CF
HM
LP
LP
HM
CF
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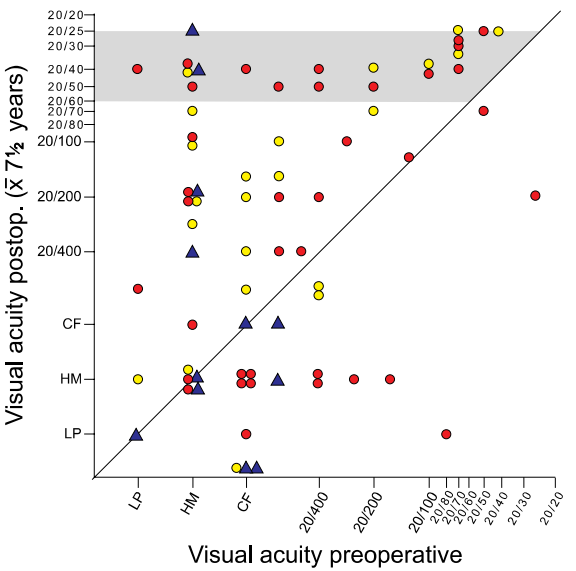
20/100
20/80
20/70
20/60
20/50
20/40
20/30
20/20
Visual acuity preoperative


Visual acuity postop. (x̄ 7½ years)
20/20
20/25
20/30
20/40
20/50
20/60
20/70
20/80
20/100
20/200
20/400
CF
HM
LP
LP
HM
CF
20/400
20/200
20/100
20/80
20/70
20/60
20/50
20/40
20/30
20/20
Visual acuity preoperative

8.18.4 Discussion

Surgery for retinal detachments complicated by PVR grades B or C can be made relatively atraumatic by limiting cryopexy and scleral buckling to the area of the break and by not draining subretinal fluid, in order to avoid a breakdown of the blood aqueous barrier. This minimal extraocular surgery actually tests for the degree of PVR.

? What does testing the degree of PVR by first attempted localized buckling mean?

- Without resort to a cerclage or vitrectomy, retinal reattachment was obtained with only 1 segmental buckle operation (a sponge or a balloon) in 79%.
- After reoperation, also without vitrectomy or an encircling band, reattachment followed in **85%**.

This implies that there is a degree of PVR that does not interfere with retinal reattachment when localized buckling of the break is applied with a minimum of surgical trauma.

In addition, after minimal extraocular surgery PVR rarely progressed, but on the contrary regressed.

Early redetachment developed within 6 months, in 6 eyes and **late redetachment, not before 9 and 11 years, in 2 eyes.**
In addition, the anatomical and functional long-term results were not jeopardized by secondary complications, such as cataract, glaucoma, or hypotony in comparison to the fellow eye.

The answers to the questions posed at the beginning of this study are therefore:

1. Minimal extraocular surgery can result in reattachment of a PVR detachment of grades B and C.
2. It can also induce regression of PVR grades B and C, and can provide long-term reattachment.
3. It can provide favorable long-term visual function.

? A further question arising might be:
How would the functional results compare to a similar series of PVR detachments in which reoperation consisted of vitrectomy with vitreoretinal surgery?

▶ When the results of the treatment of grade B and C1 PVR detachments (n = 60) in the present study were compared with a similar series (n = 66) reported by Chang et al [53], in which the initial operation consisted of segmental buckling as in the present study, but vitrectomy was used in selected cases (10.6%) at reoperation.

- There was no significant difference in the anatomical results after 6 months (Fig. 8.**55**).
- Unexpectedly, there was also no significant difference in the functional results (Fig. 8.**56**).

It may be recalled here that the 8 macular puckers in our group's series of 60 eyes with grade B and C1 PVR detachments were not operated on with vitreoretinal surgery.

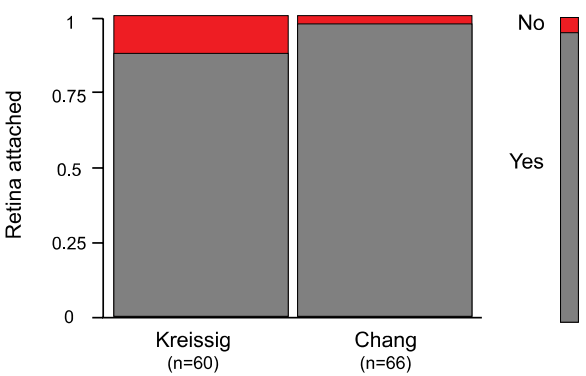


Fig. 8.**55** *Anatomical results, 6 months postoperatively,* in 126 PVR detachments, grades B and C1, treated by Kreissig et al (n = 60) using segmental buckling without drainage in both the primary operation and also for reoperation; and by Chang et al [53] (n = 66) using segmental buckling as the primary operation and additional vitrectomy with vitreoretinal surgery (10.6%) for reoperation. There were no statistically significant differences (Fisher's exact test, $P = 0.10$) between the results of the 2 series after 6 months.

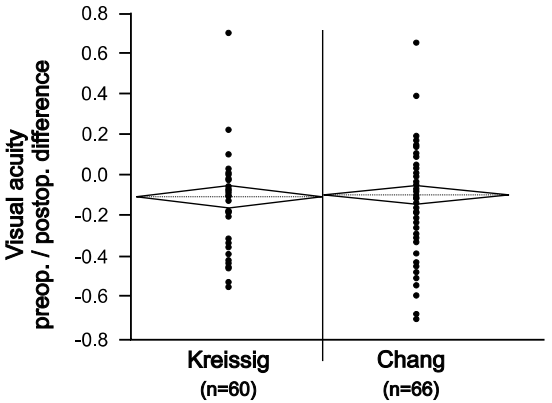


Fig. 8.**56** *Functional results, 6 months postoperatively,* in 126 PVR detachments, grades B and C1, treated by Kreissig et al (n = 60) using segmental buckling without drainage in both the primary operation and also for reoperation; and by Chang et al [53] (n = 66) using segmental buckling as the primary operation and additional vitrectomy with vitreoretinal surgery (10.6%) for reoperation. There were no statistically significant differences (Student's *t*-test, *P* = 0.083) between the 2 series after 6 months. The Kreissig series includes 8 eyes with macular pucker in which vitreoretinal surgery was not performed.

There was no statistically significant difference in the functional results, but **complications were less frequent and there was less morbidity in the eyes treated without vitrectomy.**

? What does this small, but prospective long-term study of 72 PVR detachments of moderate degree, treated with minimal extraocular surgery, tell us?

- **The most critical period for redetachment is during the first 6 months after surgery.**
- The threat of redetachment is reduced if PVR is not provoked into progression by traumatic surgery.
- If the retina is still attached 6 months postoperatively, there is little risk of redetachment in subsequent years.
- **The critical period for PVR progression is already over after 6 months.**

8.18.5 Conclusion

Since we cannot predict whether PVR in a retinal detachment will progress after surgery or not, it seems justified to use minimal extraocular surgery, i.e., segmental buckling without drainage, in the 1st attempt to treat a PVR detachment of grades B, C1, and C2.

In these vulnerable eyes with a PVR detachment, the surgical trauma should be small not to provoke a PVR progression, and to encourage the real chance of PVR regression.

Surgery for a PVR detachment should therefore be as atraumatic as possible; one should:

- Be gentle when manipulating the eye
- Limit and monitor cryosurgery
- Limit the buckle to the area of the break
- Avoid drainage of subretinal fluid
- In addition short-term systemic corticosteroids (preoperatively 50 mg–100 mg, intraoperatively 50 mg) can be administered to limit cellular reaction.

One should remember that in 8 of 10 detachments with grade B, C1 or C2 PVR:

- A segmental buckle operation will be sufficient and will result in reattachment.
- Favorable long-term anatomical and functional results can be expected.
- No late deterioration of visual function due to secondary complications will develop.

The secret of success in these vulnerable eyes with a PVR detachment is:
- Doing less to start with
- Only doing more when needed

However, if reattachment does not occur after buckling, then vitreoretinal surgery may be indicated.

8.19 Summary

Minimal extraocular surgery for treating retinal detachments represents an amalgam of numerous procedures developed during the last 50 years. A non-invasive extraocular operation was made feasible by integrating the nondrainage procedure inaugurated by Custodis in 1953. The original technique met with wide-spread acceptance after Lincoff modified it in 1965 by replacing diathermy with full-thickness cryosurgery and the Polyviol plombe with silicone sponge. With these changes the complications of the procedure were eliminated. In subsequent years there were 3 additional changes resulting in the presented minimal extraocular surgery. There were:

- **A change from intraocular to extraocular surgery** by avoiding drainage of subretinal fluid.
- **A change from surgery of the retinal detachment to surgery of the break.** The break is the cause of the detachment, the extent of the detachment can be neglected.
- **A change from circumferential to radial buckling.** Radial orientation of the buckle provides a more effective tamponade.

Radial buckling must be precise and requires an expertise in binocular indirect ophthalmoscopy to overcome the parallax, both radial and circumferential, when localizing a highly detached break. Pseudophakia or a small pupil may require preoperative study with an indirect wide-field contact lens (by Mainster, Volk and Lincoff), to detect tiny breaks in these challenging detachments.

With the nondrainage procedure, the subretinal fluid provides an assessment of the quality of surgery. If after surgery without drainage retinal reattachment occurs, it confirms that the break is closed and that no break has been overlooked. Early mobilization of the patients can follow without hesitation.

Minimal extraocular surgery is feasible in more than 9 of 10 retinal detachments and reattachment will occur in more than 9 of 10 eyes. The surgery is done in local anesthesia. The rate of redetachment will be less than 1% per year during the succeeding 15 years. Since the surgical trauma is minimal, the complications are minimal and the long-term visual function is not jeopardized by complications. Hopefully new developments in cataract surgery

will provide eyes with less capsular remnants and a larger intraocular lens for better visualization of the retinal periphery. This would reduce the need for a primary vitrectomy with its greater morbidity for the management of some pseudophakic eyes. Instead the time-tested minimal extraocular surgery with its low morbidity and favorable long-term visual results can remain the gold standard for reattaching a retina. Our philosophy is therefore:

- A small operation to reattach a retina is better than a large one.
- Two small operations are better than 1 large one.

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